SCIENCE TEACHER'S WORLD

For Teachers of Science
PLEASE ROUTE TO:

Teacher's edition of SCIENCE WORLD February 3, 1960

Using *Science World* in Your Teaching

How Old Is It? (pp. 9-11)

General Science Topic: Peaceful uses of atomic energy
Chemistry Topics: Carbon dioxide, isotopes of carbon
Physics Topics: Nucleonics, Geiger counter

About This Article

Carbon dating is a peaceful use of atomic energy that extends to a whole range of arts and sciences. It is presently being applied to history, archaeology, oceanography, geology, and other fields of interest.

In the old-fashioned hourglass, grains of sand passed from an upper to a lower chamber, and the passage of time was measured by the amount of sand remaining. Similarly, in a specimen containing carbon-14, the latter is changing into nitrogen, and the passage of time is measured by the amount of carbon-14 remaining. This is admittedly a rather crude analogy. Nevertheless, it may be helpful in trying to get the idea over to a class. The students might then be referred to the article, which describes in detail the chemical and physical procedures employed in carrying out the dating process.

Topics for Reports and Discussion

1. Explain why the carbon dating method cannot be used to determine the age of a substance or an object that is older than 70,000 years.
2. Describe a specific use of carbon dating that has been made by anthropologists, by archaeologists, by geologists, by oceanographers.
3. What part does each of the following play in the production of carbon-14 in the earth's atmosphere: cosmic rays? neutrons? nitrogen?
4. How does the atom of carbon-14 differ in structure from that of carbon-12?
5. What is the normal proportion of carbon-14 to carbon-12 in the atmosphere?
6. If carbon-14 is constantly changing to nitrogen, explain why it does not entirely disappear.
7. How long does it take for carbon-14 to change into nitrogen?
8. Explain why it takes as long as four hours to prepare carbon-14 in a specimen for dating.
9. Explain the necessity for shielding the counting-flask used in carbon-14 dating. How is this shielding accomplished?

Corrosion (pp. 12-15)

General Science Topic: Conservation
Chemistry Topics: Electromotive series, electrolytes, electrolysis, ionization
Physics Topic: Electric current flow

About This Article

"As strong as iron"—this is a common expression signifying strength and endurance. Yet iron and many other "hard" metals can fall away like sand when the electronic forces that hold together their molecules and atoms are unbalanced or neutralized. This has happened to parts of ships in sea water and to gas pipes, water pipes, and oil lines underground. The physics, chemistry, and economic importance of corrosion are portrayed in this article against a broad historical background.

Reference is made to the researches of Sir Humphrey Davy and of Michael Faraday, whose work laid the foundation for our understanding of corrosion, and it is emphasized that studies of phenomena associated with corrosion continue to this day. Such studies are being carried on by scientists in the National Bureau of Standards, by scientists associated with telephone companies, and more recently by atomic scientists.

As an outcome of these researches, some control over corrosion is being achieved by engineers. Even greater control will be achieved with the development of new research tools and methods. For example, a new element, technetium, gives promise of being useful to both the scientist and the engineer concerned with corrosion.

As a background for understanding the article, several time-honored demonstrations and devices—the lemon battery, copper-plating apparatus, the lead storage battery, and others – can be used to establish the idea that electric current, electrolytes and the corrosion of metals are interrelated, each being a manifestation, as it were, of the others.

Topics for Class Discussion

1. Explain how Sir Humphrey Davy and Michael Faraday came to be involved in the study of corrosion.

2. Describe what Michael Faraday discovered about the nature of corrosion.

3. How may one explain the corrosion of a single plate of metal in salt water?

4. Why are alloys especially susceptible to corrosion?

5. Explain why a bronze propeller on a steel ship is subject to severe corrosion. How might the corrosion of such a propeller be prevented?

6. In what way is an underground pipe like a ship in sea water?

7. Describe some of the methods by which corrosion of underground pipes is being prevented.

8. Explain the theory which accounts for the ability of technetium to prevent rusting of iron.

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A simple and illuminating demonstration to show the principles of galvanic corrosion can be made with an ordinary tin can containing acid fruit juice, such as pineapple juice. The can should have a tin lining—varnished metal won't do. When the can is opened and the juice poured out, the tin inside will be bright and shiny and the juice free of rust. If the can is washed out, filled with ordinary water, and allowed to stand for a day or two, the water will then show signs of rust.

The explanation for this is as follows: Galvanic corrosion occurs between the iron or steel and the tin coating, through minute pinholes in the coating. Iron is above tin in the electromotive series, and thus would corrode and fill the water with rust. However, fruit juice acids have complex molecules which reverse the position of iron and tin in the electromotive series, so that the tin corrodes instead of the iron. When water is poured into the can, the iron and tin return to their usual position in the electromotive series, which means that the iron now corrodes, releasing rust and coloring the water.

Fish Sleuth—Dr. Evelyn Shaw (p. 20)

Biology Topic: Animal behavior
Vocational Guidance Topic: Women in science

About This Article

This article describes the life and work of an attractive young woman who is making some significant contributions to our understanding of the social behavior of fish. After struggling through many articles that are unavoidably "technical," young readers of *Science World* will be delighted to read about Dr. Shaw and her fish studies—studies any "fish-watcher" can understand.

Teaching Suggestions

For the biology teacher, the article affords an opportunity to emphasize (1) that there is a close interrelation between the field and the laboratory in biological research; (2) that not every research biologist wears a long white coat; (3) that there are many biological investigations that can be carried on without super-microscopes and rare and expensive chemicals; (4) that there is no contradiction between being a scientist and being an attractive young woman.

One way of introducing this article in class is to recall observations of fish swimming in "schools," and then to raise for discussion the question: "Is this form of behavior inherited or is it acquired? The question may engender some rather lively discussion, leading to a point where the teacher might interject the question: How can this question be answered *experimentally*? After considering some proposed "experimental designs," the teacher might refer the class to this article, which describes how *one* scientist has attempted to find the answer.

Comprehending Scientific Reading (p. 26)

What can a science teacher do to improve the ability of his students to read with comprehension scientific literature, whether it be a textbook, reference book or magazine? The most potent thing he can do is to provide a background of *experience* with the phenomena that are the subject matter of the reading.

With students who have a reasonably adequate background of experience, reading selections such as those suggested by Dr. Benjamin can be used with some validity to test ability to comprehend scientific writing.

—Z.S.

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Embryology—Life Before Birth (pp. 5-8)

Biology Topics: Reproduction, embryology, cell specialization

About This Article

The study of an egg developing into an embryo with recognizable features is an experience most students will find exciting.

This article describes the series of events which are triggered by the union of sperm and egg. The process of development is carried up to the beginning of the ninth week after fertilization. The changes which occur in the developing embryo are explained. Numerous illustrations of different stages

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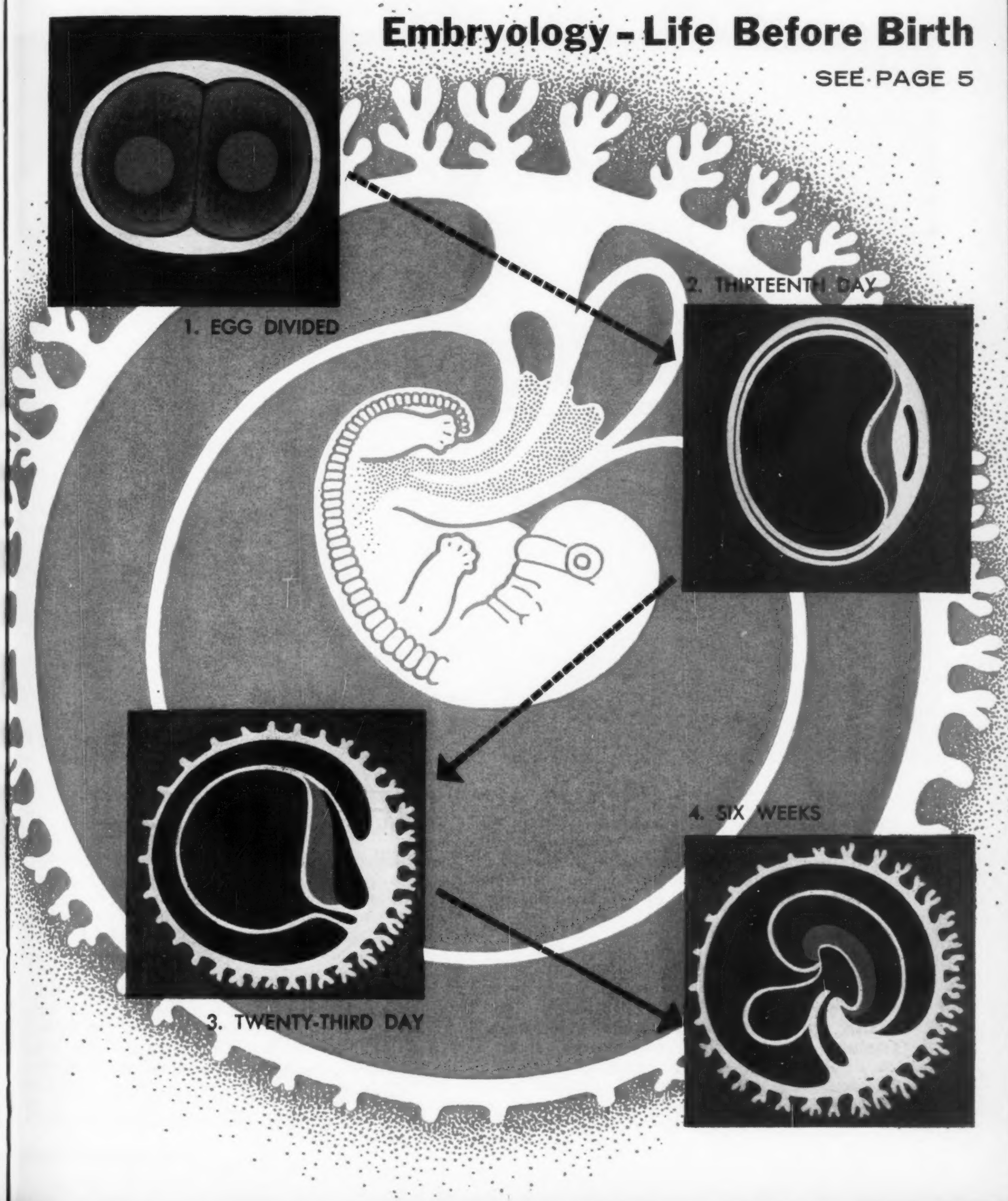
Embryology – Life Before Birth

SEE PAGE 5



The cars are safer . . . the roads are safer . . .

THE REST IS UP TO YOU!

"Don't worry, Mom, we'll be careful." She says it as you're walking her out to the car. And what a responsibility this means for *you*, the driver! Her folks, your folks, the parents of everyone riding with you depend on your safe driving ability and mature judgment. And their confidence is shared by the officials who issued your license to drive.

Of course a lot of people are working constantly to *help* you drive safely. Automotive engineers actually *design* safety into today's cars . . . power brakes, better suspension systems, more visibility, improved lighting. Traffic experts contribute well-marked intersections, divided highways, grade separations and other built-in aids to safer driving.

Yes, you have a lot of help, but once you're behind that wheel, the rest is up to you! Fortunately, it's just as easy to be a safe driver as it is to be a good citizen . . . in fact, many of the same qualities are needed. You merely practice courtesy, alertness, caution and respect for the rights of others . . . and you play by the rules. In *driving* this pays off in *safety* for you and your friends . . . and in more frequent opportunities to use the car.

GENERAL MOTORS A CAR IS A BIG RESPONSIBILITY—SO HANDLE WITH CARE!

SCIENCE WORLD

FEBRUARY 3, 1960 • VOLUME 7 • NUMBER 1 • A SCHOLASTIC MAGAZINE

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C O N T E N T S

Features

Departments

Science in Quotes

Great theories in science are always great inventions—products of the imagination. The universe is an invention, the atom is an invention. There are more conceptions of the universe than there are models of automobiles. Some have a wide sweep that exceeds any act of creation described by a poet. . . .

When a colossal idea bursts in the mind it overwhelms. . . . Einstein has stated that his first paper on relativity came to him "like a storm breaking loose." Just how he felt when he arrived at the simple algebraic equation which declares that matter can be converted into energy and energy into matter he has not told us. A man of his deep insight must have been stunned. Nothing in Dante's *Inferno* matches it for evil and horror—nothing promises so much material happiness and good. —WALDEMAR KAEMPFFERT

Letters

Bacteria in the Mouth

Dear Editor:

I have just finished reading *Microbe Hunters*. The book stated that Leeuwenhoek found that after drinking a hot liquid all the bacteria in his mouth died. If this is true, why don't we use hot water instead of toothpaste for destroying bacteria in the mouth?

Martha Lynn Einhorn
New York 9, New York

Answer: Hot water does not kill all the bacteria in your mouth. You must remember that the resolving power (magnification) of Leeuwenhoek's crude microscope was not very good. Many bacteria cannot even be seen with an ordinary microscope. To observe bacteria adequately a high-powered optical microscope or an electron microscope must be used, together with staining techniques unknown to Leeuwenhoek.

Icebergs, Fresh or Salty?

Dear Editor:

What are icebergs made of, fresh water or salt water?

Howard Hirae
Kau High School
Pahala, Hawaii

Answer: Most icebergs are actually pieces of glaciers. Glaciers are slow moving rivers of ice formed by falling snow. When the glaciers reach the open sea, they break into icebergs. Since these were made of snow, they melt into fresh water.

Another kind of ice found in the sea is made of frozen sea water. This is called floe ice when in loose pieces, and pack ice when packed together. Sea water freezes at a temperature of about four degrees below zero F., and this ice is rarely more than eight or ten feet thick. The ice formed from salt water contains almost none of the salt. As the ice forms, the salt ions are left in the remaining water, making it more salty. Therefore, if you melt floe ice or pack ice, the water will not taste salty.

The First Meter

Dear Editor:

How was the length of the meter originally determined?

Judy Carroll
Haliburton, Ontario,
Canada

Answer: The meter was originally intended to be one ten-millionth of the length of a meridian running from the North Pole through Paris to the Equator. But it was soon found that to measure this length accurately would be a very difficult undertaking. Instead, an arbitrary standard of approximately the same length was decided upon. A platinum bar of this length served as the first standard meter, and in 1889 a platinum-iridium bar was used, with two lines traced on it exactly one meter apart. This bar is kept in a subterranean vault of the International Bureau of Weights and Measures, at Sevres, France.

Today a natural standard for the meter has finally been established. It is determined by counting a certain number of wave lengths of a special red light found in the spectrum of cadmium. This standard is at least as accurate as the platinum bar, and can be checked at any time any place on earth.

Frost on Windowpanes

Dear Editor:

Would you please explain why frost forms such fascinating patterns on windowpanes when the outside temperature drops way below zero?

Ervin Derkatch
Canore, Saskatchewan
Canada

Answer: Frost will form on windowpanes when the air in a room is carrying a fair amount of moisture, and when the air outside is cold enough to keep the window glass at a temperature below freezing. The moisture in the room air condenses on the freezing windowpane in the form of tiny liquid droplets which quickly freeze. As the frost spreads, it will form leaf shapes or fern shapes, swirls or crystals.

No one knows exactly what causes windowpane frost to form in such a variety of designs. The frost will often follow the direction of scratches in the glass, or will form on invisible films of dust or soap left from washing. Some scientists think that such films on the windowpane make the water molecules freeze into the complicated frost patterns we see.

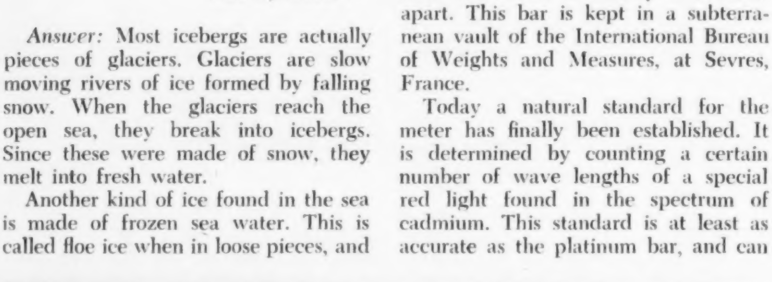
Matter and Energy

Dear Editor:

The law of conservation of matter and energy states that matter is a form of energy, and energy is a form of matter. That is, matter and energy are interchangeable. If this is so, has energy ever been changed into matter?

Peter Andreyuk
Archbishop Walsh H. S.
Irvington, New Jersey

Answer: Scientists have shown that matter can be changed into energy, as in the hydrogen and atomic bombs. In a nuclear reaction, a small amount of mass is transformed into a great deal of energy. However, scientists have not yet been able to turn energy back into mass, although they believe that it will someday be done. Some astrophysicists think the process occurs in outer space, where light energy may be changed into hydrogen atoms.



Drawing by Corydon Bell from Snow, by T. H. Bell (Viking)

Pattern of frost on windowpane often follows direction of scratches in glass.

By RICHARD BRANDT

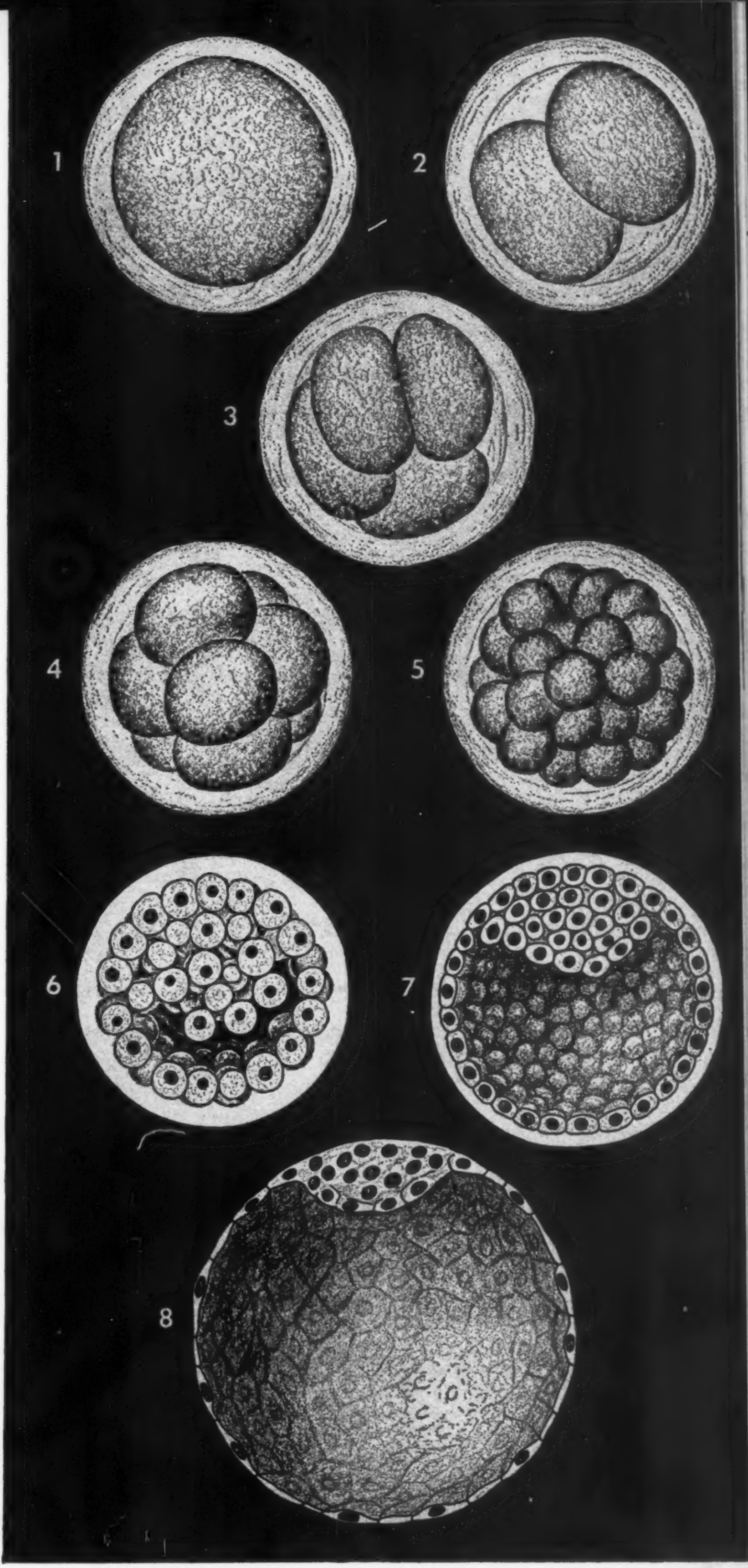
EMBRYOLOGY
Life Before Birth

UNDER the skin on either side of the developing brain of a frog are a pair of structures called eyecups. As the eyecups gradually grow outward from the brain, the skin which covers them thickens and changes into rounded structures. These structures break away from the skin cells and enter the eyecups. They become the lenses of the eyes.

If at a very early stage of embryonic development an experimenter removes one of the eyecups and transplants it under the skin of the frog's belly, an interesting event occurs. The lens of the eye develops just as well there as it would in its normal position. However, the skin at the original site of the eyecup does not develop a lens.

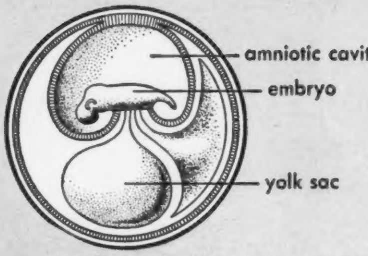
How does this occur? Scientists have only recently, within our own century, begun to ask and seek answers to such questions. This experiment, first carried out by the biologist Hans Spemann about 50 years ago, illustrates one of the dramatic discoveries of a branch of biology called Experimental Embryology.

It was Aristotle, the Greek philosopher-scientist (384-322 B. C.), who first opened hen's eggs at various stages of their incubation and re-



During cleavage, fertilized egg divides without changing its size. It continues to divide in this way until sphere of about 16 cells is formed. (1) Fertilized egg is shown before division. (2) Two-cell stage. (3) Four-cell stage. (4) Eight-cell stage. (5) Multiple cells form without increase in size. (6) Cell growth begins as outer layer of cells increase in area, forming blastocyst. (7) Cavity begins to form and outer layer of cells splits off. (8) The inner cell mass becomes attached to one side of the cavity.

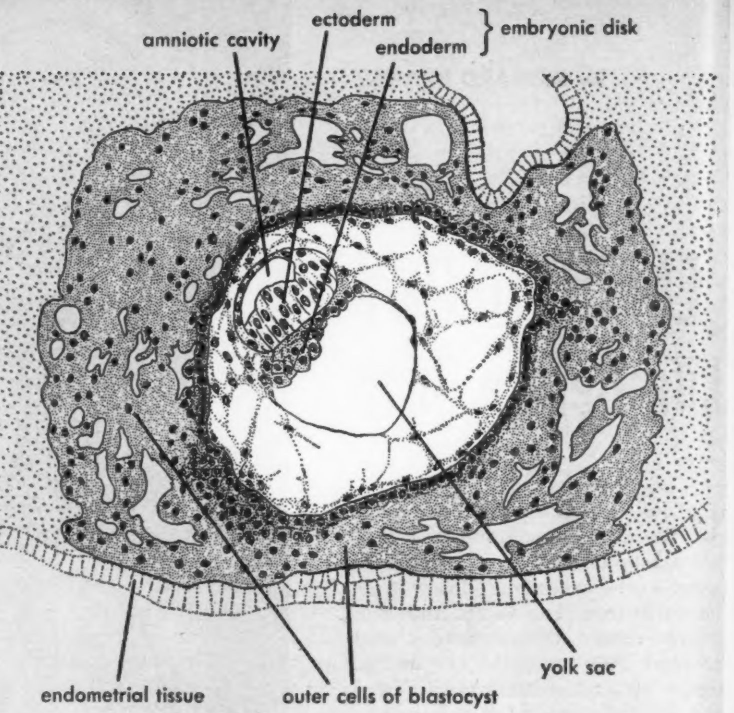
Human Organism and the World of Life (Harper)



Life, by Simpson, et al. (Harcourt, Brace)

At *right* is drawing of cross-section of the blastocyst. As the blastocyst implants itself within endometrial tissue, the amniotic cavity, the embryonic disk, and the yolk sac are formed in the inner cell mass. This cross-section shows structures forming in eleven-day-old human embryo.

***Above* is a schematic diagram illustrating the cross-section at right.**



Human Organism and the World of Life (Harper)

corded his observations. Since that time the study of embryology has been concerned with recording the *changes taking place as an organism develops.* Although a great deal of information has been gathered by embryologists, our knowledge has only skimmed the surface of the subject.

What happens in a developing embryo? And how do these changes occur?

Think of any plant or animal in the world. Each was introduced into the world by life which preceded it. Each new organism was produced by either one parent or two. But wait a moment, you say, what about amoeba and other one-celled animals? Do they have parents? They do, but when amoeba and other protozoans reproduce, by means of fission, the parent, which is one-celled, divides into two new cells.

Organisms that arise from one parent are reproduced asexually. Among higher plants and animals sexual reproduction, which involves two parents, is much commoner.

To produce a fertilized egg, ordinarily two special cells (known as germ cells) are needed. In animals these cells are the sperm and the egg. Of the millions of sperm cells that approach the egg cell, only one sperm may enter it. All the others will die.

The union of sperm and egg triggers a long series of processes which change the fertilized egg, whose diameter is about 1/125 of an inch in man, into an adult organism. In mammalian embryology, an early step in this chain of events is a process called *cleavage*. Cleavage results in the division of the initial cell into two, then four, then eight cells.

Each Cell a Specialist

This division continues until the fertilized egg forms a small mass of cells within the egg. At this stage, the total size of this mass is no greater than that of the original fertilized cell. In each of the tiny cells can be found a complete set of chromosomes bearing the hereditary characteristics of both parents.

The original cell (the egg) is now broken up into many separate cellular units, each with its own nucleus. Now, with many nuclear centers present, a number of special activities begin. Each cell performs a particular task.

The cells of the human embryo, most of which are uniform in size, begin to increase in number. As they do, their arrangement takes the form of an *irregular* mass. These individual cells are known as *blastomeres.*

Eventually the outer blastomeres form a distinctive layer which encloses spherical central cells.

The cells absorb nourishment and the embryo begins to grow. Cell division now proceeds more rapidly. The outer layer of cells divide at a more rapid rate than the interior cells. The outer cells begin to separate from the interior cells on all but one side. As the outer layer's area increases, it forms a hollow sphere. The interior cells (called the inner cell mass) will give rise to all the cells that are to take part directly in forming the embryo. The entire structure is now called the blastocyst.

From the earliest division of the fertilized egg to the beginning of the ninth week after fertilization, the organism is called an embryo. During this period, a group of flat plate-like cells have been developing into a minute human being about an inch in length, weighing about 1/25 of an ounce. When this stage of development passes, the organism is called a fetus. We will concern ourselves only with the embryonic stage of development.

The embryo grows to about one hundredth of an inch in diameter after about the sixth day of its development. The egg membrane disintegrates and the blastocyst becomes

attached to the surface of the endometrial lining, the membrane which lines the uterus. Enzymes now are produced by the outer layer of the blastocyst cells. These enzymes destroy the endometrial tissues of the uterus. This destruction of tissue enables the blastocyst to implant itself into the endometrial lining. The outer layer of cells is now growing and dividing rapidly.

Cell Migration

As the process of implantation takes place, a small cavity forms between the outer layer of cells and the inner cell mass. This is the amniotic cavity, which will in a short while become the enclosure in which the embryo is held during development.

A second cavity known as the yolk sac grows out from the inner edge of the inner cell mass. Two layers of cells, called the embryonic disk, lie between the yolk sac and the amniotic cavity. These two cell layers will develop into the embryo. The other parts of the blastocyst become nutritive and protective structures. These structures surround the embryo and later the fetus.

The cells in the upper layer of the embryonic disk multiply rapidly. The newly formed cells migrate between the two layers of the embryonic disk and form a third layer. There are now three layers, known as the germ layers. These are the ectoderm, the entoderm, and the mesoderm. Each of these three layers will give rise to certain specific tissues.

The chart at the right lists the structures formed by the germ layers. As the primitive germ layers become specific tissues, the embryo increases in size. The various organs and systems which carry on the life processes of the adult animal become established.

When the fertilized egg divides, as we have seen, it forms two identical cells. Each has the shape and properties of the original cell. It continues dividing again and again. If cells always divide identically, how do some of them become nerve instead of muscle, heart instead of skin, lungs instead of blood?

Dr. James Ebert, Director of the Department of Embryology at the Carnegie Institution of Washington, tells us that scientists still do not know the answer. They do know, however, "that these things are determined within the individual cells and its molecules. We've known for a long time that cells specialize. We've also known that as the embryo is formed, cells move from one part of it to another."

THREE GERM LAYERS	
ECTODERM	nervous system (brain, spinal cords, nerves, receptor endings)
	lining epithelium of mouth and nasal cavities and last part of rectum
	epidermis and its derivatives (hair, nails, enamel of teeth, lens of eye)
ENDODERM	lining of almost the entire digestive tract, lining of tubules of pancreas and liver
	lining of respiratory system
MESODERM	voluntary muscles
	derma (in part)
	skeleton (in part)
	involuntary muscles of digestive tube
	circulatory system
	excretory system
	sex glands
	linings of body cavities

Science World graphic

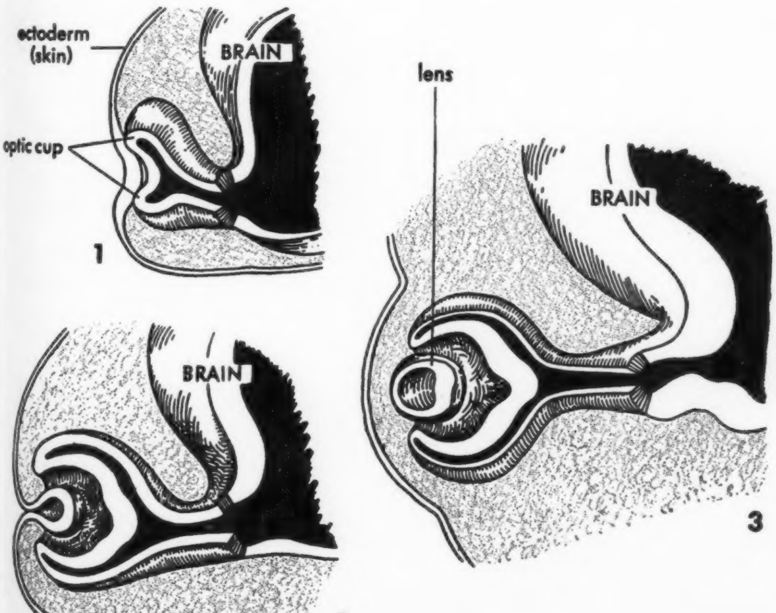
Each of the three germ layers in embryonic disk gives rise to specific tissues.

How are these cells put together into unified working organs? Dr. Robert DeHaan, one of Dr. Ebert's associates at the Carnegie Institution, has been studying cell migration in an effort to find out whether there are substances which bind cells together in specific ways. His experiments suggest that there are clearly defined patterns of cell migration.

Cell Experiments

Let us study one of Dr. DeHaan's experiments in detail. Dr. DeHaan cut into tiny fragments a chick embryo in which the heart had not yet been formed. He then proceeded to cultivate each of these fragments in a tissue culture dish. Dr. DeHaan found that some of the fragments grew into tiny pulsating masses of heart tissue. When he performed the same experiment on embryos in progressively later stages of development, he found that the areas from which heart tissue develops are constantly changing in position in the embryo.

In a newly laid egg the heart cells appear to be distributed around the edge of the embryonic disk. As development progresses, they move to take up a position in the mesoderm layer. Dr. DeHaan's experiments indicate that certain kinds of cells follow what he calls a "predictable pat-



Human Organism and the World of Life (Harper)

Section of developing brain of frog—(1) Eyecup grows outward from brain. (2) Skin over it thickens, breaks away from skin cells, enters eyecup. (3) Skin forms lens.

Photos from Dr. James Ebert, Dept. of Embryology, Carnegie Institution

***In photo at left*, normal heart in chick embryo is seen to resemble pouch-like structure protruding toward the right of chick's mid-line. *Photo at right* shows a chick embryo that has been treated with acetylcholine, producing double-hearted embryo. Experiments conducted by Dr. Robert DeHaan indicate that acetylcholine interferes with merging of paired embryonic structures. Right chick is 37 hours old.**

tern." They eventually come together to form a pulsating heart. The question that still remains to be answered is: when do they become heart cells?

It had been theorized that the heart-forming cells had to reach a given destination before they would take on the characteristics of heart muscle. Dr. DeHaan has performed an experiment to prevent heart-forming cells from reaching their destination, to see whether these cells would become some other kind of cell. In this experiment a chick embryo of about 26 hours of development (this is equivalent to a human embryo of about three weeks) has a micro-surgical incision made in the tissue that ordinarily brings together the two heart-forming masses. The incision was made to prevent them from coming together. Twenty-four hours later the embryo had one heart on either side of it, each beating separately. Dr. DeHaan established in this experiment that long before the heart was beating—even before it was formed—there were already cells which were specialized to become heart tissue.

Many experiments have been performed by researchers to learn more about the developing embryo. For example, frogs' eggs have been punctured with a needle previously dipped in tissue fluid. Activity immediately started in the protoplasm of the egg. Cleavage of the egg took place, and from that stage on the process of embryonic growth continued through the tadpole stage and metamorphosis. (Tissue fluid is prepared by breaking down tissue, as in a centrifuge.)

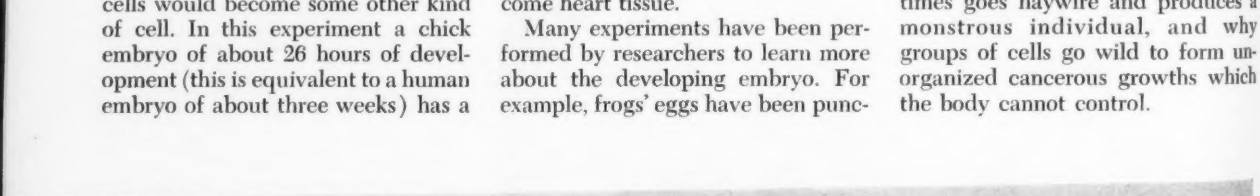
These and other experiments indicate that no matter what activating stimulus is used—sperm, electric shock or chemical stimulus—all the members of a species will react in the same way to the same type of stimulus. Once a stimulus activates the unfertilized egg and the process is started, it may continue until a new organism is formed.

Fledgling Science

In another experiment, bits of embryonic tissue were transplanted from one embryo to an unnatural position within another embryo. The embryonic bud of a tadpole, which would normally grow into a leg, still formed a leg when transplanted to the back of another tadpole.

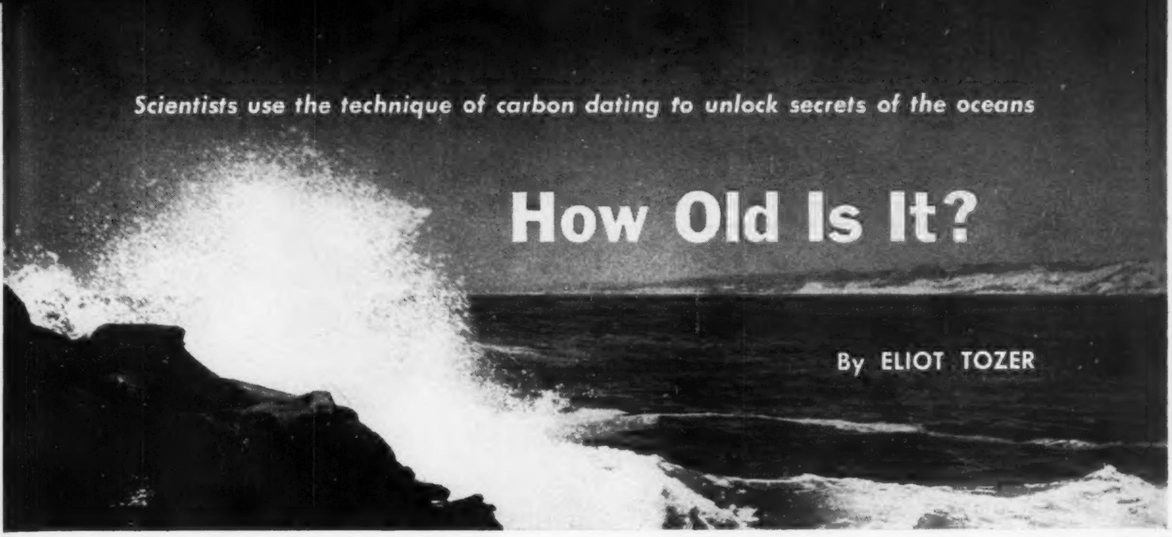
However, there is one special period during which this can occur. After that period passes, the internal mechanism of the embryo is unable to carry out the original structural design, should the normal course of development be interrupted. The region responsible for directing these internal operations is called an *organization center*.

Embryology is a fledgling science. It is pushing back old frontiers, seeking to find the answers to why the development of an organism sometimes goes haywire and produces a monstrous individual, and why groups of cells go wild to form unorganized cancerous growths which the body cannot control.



Columbia Encyclopedia (Columbia University Press)

Series of drawings show various stages in the development of hen's eggs from early stages to the clearly defined fetus.



Scientists use the technique of carbon dating to unlock secrets of the oceans

How Old Is It?

By ELIOT TOZER

NOT long ago, a sleek schooner sailed into the choppy Caribbean waters where pirates once plundered rich galleons from Spain. There she hove to in the lee of a small, unnamed island. Her crew, burned black by the sun, broke out a strange barrel from below decks, made it fast to the lines of the davits, and lowered away.

For several minutes, a steel cable leaped out of the whirling drum on the deck and hissed down into the warm and murky water. The skipper, ticking off the footage, yelled, "Six hundred!" and the line slowly came to a stop. Two of the crew heaved on an auxiliary line. Far below, the ends of the barrel snapped shut.

"Haul away," yelled the skipper.

Up from the deep, 100 fathoms down, came a barrelful—of sea water.

There was nothing special about the water, or at least the crew did not think so, but they labeled their sample with care: date, time, place, and depth. For this was the good ship *Vema*, a three-masted, floating research laboratory. Her crew was made up of members of Columbia University's Lamont Geological Observatory at Palisades, New York. One of their jobs: to collect samples of sea water from many parts of the world. The purpose: to find out how long ago the water in deep masses left the surface, thus determining how long it takes sea water to mix—unlocking, hopefully, one more secret of the circulation of the oceans.

How do you date a sample of sea water? Does a gallon of Caribbean water look, taste, or feel any older than another?

Scientists determine the age of sea water by a technique called radiocarbon dating. Developed by former U. S. Atomic Energy Commissioner Willard F. Libby, radiocarbon dating can determine the age—up to 70,000 years under the best conditions—of water, a piece of wood, or shoreline ooze—by measuring the rate of decay of carbon-14 atoms within it.

Scientists have turned eagerly to the new technique. Archaeologists have dated temple relics and ancient pottery (C^{14} witnessed to the authenticity of the Dead Sea scrolls). Anthropologists have followed the restless wanderings of primitive man. Geologists have made some startling discoveries about the glaciers that crunched through Milwaukee—or, at least, where Milwaukee now stands—during the last Ice Age. Although they had thought the most recent Ice Age ended 25,000 years ago, radiocarbon dating shows that the Great Lakes were chock-full of glacial ice less than 10,000 years ago. Says Dr. W. S. Broecker of the Lamont Observatory, "Radiocarbon dating has been tremendously valuable to many of the sciences."

How can radiocarbon "tell time"?

Knowing from laboratory analysis how fast radiocarbon decays (as we shall explain in detail later, it has a half-life of about 5,600 years), Dr. Libby figured he could determine the age of a sample by measuring the amount of radiocarbon left in it. But first he had to find out whether

Wide World; Lamont Geological Observatory photo

Schooner *Vema (right)* is floating lab for scientists. In photo above sample of sediment and water is studied by Dr. John E. Nafe *(right)* senior scientist aboard *Vema*.

radiocarbon existed in nature, as was suspected. Then he had to develop a way to measure it. His investigation is a brilliant example of scientists at work.

As a nuclear chemist, Dr. Libby knew that cosmic rays bombard earth's upper atmosphere with billion-volt energy. The violent collisions of these charged particles with upper air molecules produce neutrons. These, in turn, collide with atoms of nitrogen, the most abundant gas in our atmosphere, changing some of them to carbon by displacing one of the positive protons in the nitrogen nucleus. But this newly-formed carbon is a very special kind. It has a weight of 14, not the usual 12. Because of its heavy atomic nucleus, it is unstable. We call it radiocarbon (C^{14}).

Now, in the normal chemistry of the atmosphere, reasoned Dr. Libby, this radiocarbon must combine with oxygen to form carbon dioxide. And carbon dioxide, of course, will dissolve in the ocean as well as be built into plant tissue. The infinitesimal amount—one radiocarbon atom for every trillion (million million) normal (C^{12}) carbon atoms—makes it extremely difficult to find and measure radiocarbon, as we shall see, but Dr. Libby did it.

The Half-Life Timetable

To this point in his investigation, Dr. Libby was merely spinning theories. Now he set out to find the one-trillionth part of radiocarbon in nature, and decided to look where it might be most concentrated—in sewer gas that was enriched by being put through special equipment. He finally did find it, and it was in about the amount his theories predicted.

How did he use it to tell time?

As we have seen, radioactive carbon atoms are unstable. They tend to throw off an electron from the nucleus and change back to nitrogen again. Eventually, they succeed. These radioactive discharges can be sensed by an instrument such as a Geiger counter. And the rate of decay can be used to tell the age of the sample.

Here's how.

Radiocarbon has a half-life of 5,568 (plus or minus 30) years. In other words, in 5,568 years, half the radiocarbon in any sample disappears. In the next 5,568 years, half of the remainder decays, leaving one-quarter of the original, and so on until all the radiocarbon is gone. Knowing this, Dr. Libby had only to measure how much of a sample's original radiocarbon remained and he had that sample's age. He first tried out his new method with samples of known age, and was delighted to find his ages checked out with those put forth by the archaeologists.

But measuring the radiocarbon in a sample of sea water is a delicate laboratory technique. The idea of applying the radiocarbon method to problems of deep ocean circulation was first conceived by Dr. Maurice Ewing, director of the Lamont Geological Observatory, and Dr. J. Lawrence Kulp, head of the observatory's Geochemistry Laboratory. Here's how the researchers at Lamont do it.

On board the *Vema*, the crewmen pour their 100-gallon sample into a plastic tank, add half the contents of a standard nine-pound bottle of concentrated sulfuric acid (to release the dissolved carbon dioxide) and reabsorb the resulting gaseous carbon dioxide in a potassium hydroxide solution. This clear, syrupy potassium carbonate, dissolved in an excess of potassium hydroxide solution, is shipped to the observatory in Palisades, New York, in small steel containers.

Here Ed Olson, a pleasant young graduate student at Columbia, takes over. Ed is writing his Ph.D. thesis on the problems of contamination in the radiocarbon dating process. He gives each sample a number, let's say L-505, the "L" standing for Lamont (to distinguish it from laboratories in other cities of the world), and carries it to the white-walled lab where the wheeze of vacuum pumps and the whir of warm air blowers fill the air.

Step-by-Step in the Lab

To release the carbon dioxide from the potassium hydroxide solution, he pours it into a flask attached to an air-tight system of glass tubing that looks like a spider web. Next he evacuates the system with a vacuum pump. When phosphoric acid is dripped into the flask, the potassium hydroxide is neutralized and gaseous carbon dioxide flows upward through a condenser cooled by tap water (to remove some of the moisture), and into glass traps immersed in Dewar flasks filled with liquid nitrogen (to turn the gas to "dry ice" for easy handling).

This first step, preliminary purification, takes about one hour.

Since the counting of the emissions from radiocarbon is so critical, the researchers must remove all impurities (water vapor, oxygen, nitrogen oxides, sulfur dioxide, and halogens) that might weaken the pulse so much that it could not be detected by the counter. Carefully, Ed turns off his vacuum pump, removes the "bulb" of dry ice, and connects it quickly to another air tight system.

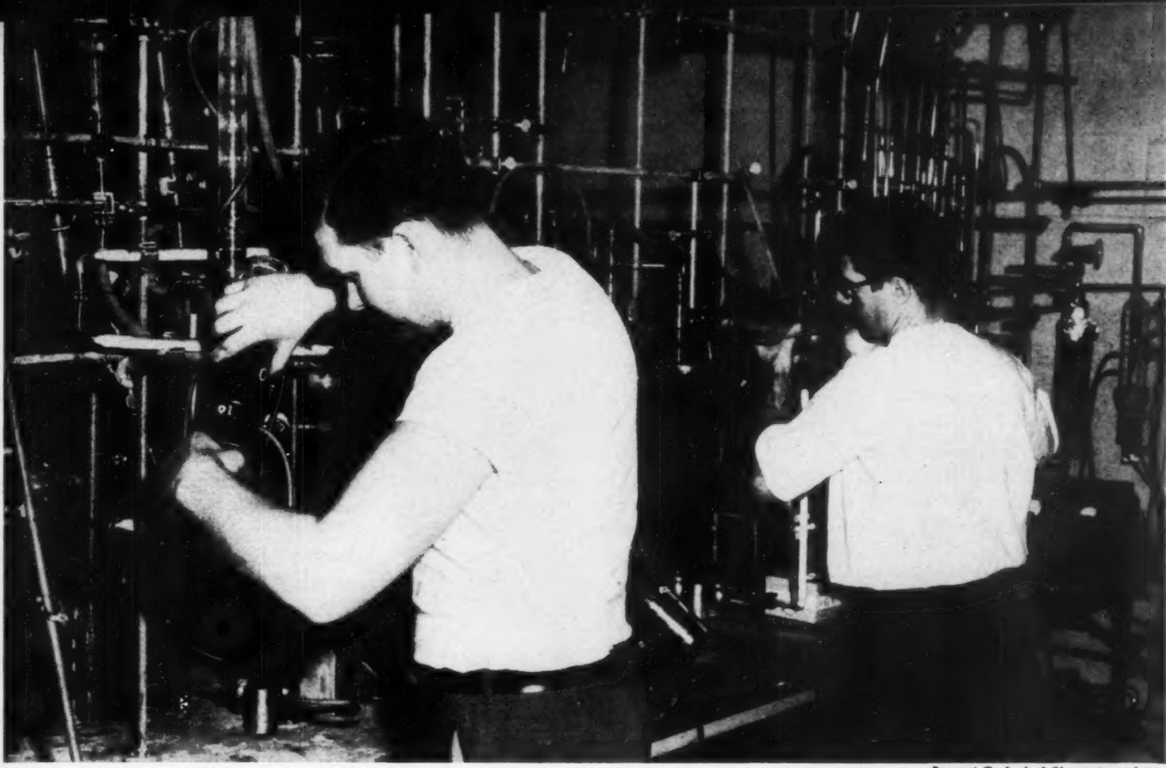
From Dry Ice to Counter

This time the carbon dioxide (he vaporizes the dry ice with an ordinary hair dryer) is drawn into a quartz tube (by vacuum), where it reacts with calcium oxide at high temperature (700 degrees C.) to form calcium carbonate. The impurities, which do not react with the calcium oxide, are then pumped away. "After an hour of pumping," says Ed, "the pressure in the system is only one micron as compared with atmospheric pressure of about 760,000 microns."

To release the carbon dioxide from the calcium carbonate, temperature is raised to 900 degrees C. inside the quartz tube by an electric furnace. The gas, collected again in the frigid traps, is now ultra-pure and ready for the counter. Total time: about four hours.

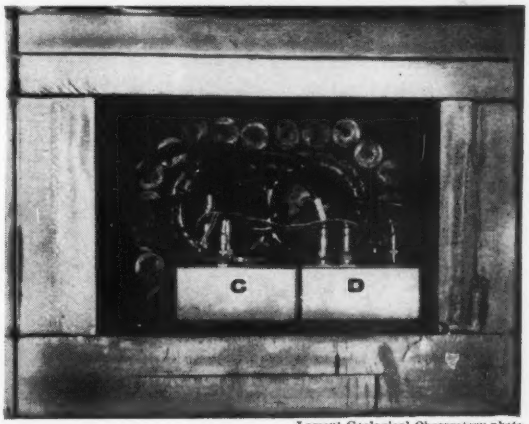
Ed and his fellow technicians, Mary Lou Zickl and Jim Hubbard, can also release the radiocarbon from sea shells (acid dissolves the shell and releases the carbon as gaseous carbon dioxide), and from chunks of wood. Careful burning in a stream of oxygen converts the wood carbon into carbon dioxide. The gas is then purified and sent on to the counting room.

Now Ed warms the dry ice again, turning it back to carbon dioxide gas, which then flows into either of two five-liter proportional counters until the pressure is one atmosphere.



Lamont Geological Observatory photo

Jim Hubbard *(left)* and Ed Olson at Lamont Geological Observatory prepare to release oceanic carbon dioxide from potassium hydroxide solution. Hubbard is pouring solution into flask, while Olson pours liquid nitrogen (—190°C.) into thermos-type container which provides low temperature needed to freeze out evolved CO_2 as dry ice. At upper left is reservoir from which acid is added to neutralize hydroxide solution. Hair dryer on lab table hastens dry ice volatilization.



Lamont Geological Observatory photo

Right—End view of counting chamber in which radiocarbon concentrations are measured. CO_2 gas enters two counters by tubes at right. When proper pressure is attained, counting of decaying carbon-14 atoms begins. Individual pulse produced by each decaying atom is amplified in boxes labeled C and D, then piped out to further amplifiers through coaxial cables leading to left. Reduction of spurious pulses is attained by outer iron shielding, by figure-eight container filled with mercury, and by circle of smaller Geiger tubes.

Like the Geiger counter, each of these counters consists of a metallic cylinder with a positively charged wire of tungsten at its center. When electrons are ejected from disintegrating radiocarbon atoms, they are attracted to the center wire and trigger the counter. Each triggering is counted electronically.

This counting equipment is far from simple. Background radiation (from mesons, neutrons, alpha, and beta particles) must be "bucked out." Since no practical amount of shielding can stop mesons, the counter is surrounded by a ring of smaller Geiger counters, so interconnected that an intruding meson shuts off the entire system momentarily and cannot be counted. To block out gamma radiation, the counter system is housed in an "iron tomb" whose walls are eight inches thick. For added insurance, an inch-thick mercury shield surrounds the counter just inside the ring of Geiger counters.

The sample is "run" for 1,000 minutes (overnight), stored again, and run another thousand minutes several days later. By comparing the count rate of the radiocarbon sample with the count rate of a chunk of wood cut in 1890, Ed Olson can estimate how long ago the sample of sea water hauled from the bottom of the Caribbean by the crew of the *Vema* left the surface.

Early indications are that it takes several thousand years for ocean water to be thoroughly mixed, and that the age of the carbon in the upper ocean—a couple of hundred fathoms deep—is about 600 years.

With Lamont's present equipment the practical limit to accurate radiocarbon dating is 45,000 years. At this age, the actual counts due to radiocarbon disintegration are of the same order of magnitude as the variation in the counts due to background radiation. But radioactive isotopes derived from uranium may extend the technique.

More and more, scientists are using the "atomic clock" to answer the fundamental scientific question: "How old is it?"

By MICHAEL DADIN

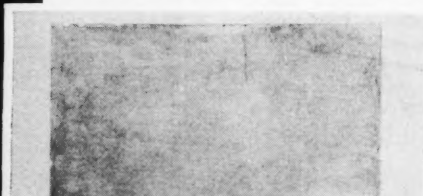
Scientists are seeking ways to keep structures from turning into skeletons

CORROSION

IN THE eighteenth century the fighting ships of the British Navy were often called "The Wooden Walls of England" because they protected the British Isles against invasion. The British men-o'-war ruled the seas and seemed invincible. Their stout oak hulls and heavy cannons could outfight the ships of any other nation.

As the British Empire expanded and its navy began sailing in tropical waters, the ships met one small but deadly enemy—the teredo worm, or marine borer. The teredo is a tireless little creature which attacks a ship below the waterline and bores holes in the wood. A healthy teredo borer can penetrate planking at rates up to one inch per week. A determined attack by teredo worms can turn a wooden ship's hull into a spongy mass, weakening the ship to the point where it has to be scrapped.

Left—Scientists of National Bureau of Standards bury metal samples to test corrosion. Samples will be dug up 17 years later. Bureau has been burying samples of materials for 45 years, has 125 test sites through U. S., to study effect of different soils. Shown below are samples of alloy steel dug up after 14 years.



National Bureau of Standards photos

Photomicrograph, *left*, shows start of corrosion. Dark areas are oxides forming on surface of a single copper crystal.

To combat the teredo, the British Admiralty ordered all wooden naval vessels to be sheathed with copper. The copper sheets stopped the teredo, but other troubles developed. The copper sheets on the hull were severely corroded by sea water. The more turbulent the sea, the greater the corrosion.

The Admiralty decided to send a test ship, the *H.M.S. Alarm*, on a 20-month voyage to the West Indies. The ship returned from its voyage with the copper plates on the bow completely wasted away. Only the edges of the sheets and the fastening bolts remained. The copper on other areas of the ship's hull remained in good condition, but it lasted only four or five years.

Zinc to the Rescue

At that time ships often sailed on voyages that stretched several years. If the copper plates corroded during that time and could not be replaced, the ship would be lost. Also, the expense of continually replacing the copper plates was great. The Admiralty realized that if the "wooden walls" were to protect England against invaders, something would first have to be done to protect the "wooden walls" against corrosion and the teredo.

In desperation, in 1823 the Admiralty called upon the British Royal Society for help. The Royal Society was the most learned scientific group in England. The president of the Royal Society, the famous scientist Sir Humphrey Davy (1778-1829), explored the problem. After intensive research Davy came up with a simple solution: He showed that by attaching small blocks of zinc to the copper sheets he was able to stop

the corrosion. The blocks of zinc, he explained, made the copper sheathing "negatively electrical," thus preserving it at the expense of the zinc. The zinc would corrode, but it could be easily replaced.

The method developed by Davy is still in use today to protect ships' hulls against corrosion. It is called cathodic protection, and is used on large and small ships throughout the world.

Davy's zinc blocks stopped the copper sheathing on men-o'-war from corroding. But the copper bottoms began to accumulate heavy growths of seaweed and shellfish. Apparently, the corroded copper had been poisonous to marine life, and had kept the sea growths from forming. Eventually, the heavy fouling of the zinc-protected copper forced the Admiralty to abandon the plan.

Electricity—the Culprit

If Davy and the Admiralty had known more about the chemistry of marine life, their method would have been successful. Modern research has shown that if copper is allowed to corrode slightly—at the rate of 5 milligrams per 100 square meters per day—fouling by marine organisms is stopped completely. Apparently, this slight quantity of corroded copper is sufficiently poisonous to kill marine growths.

Although Davy failed to protect Britain's navy, his research inspired his brilliant pupil, Michael Faraday, to identify the electrical nature of corrosion.

As a young man Michael Faraday was a bookbinder. His tremendous curiosity, however, drove him to read the books he handled, and eventually he became the most respected scientist in England. He had one important quality all scientists must have—persistence. Where Davy had tried a dozen experiments, Faraday performed thousands. He passed electric currents through all kinds of solutions until he discovered the laws of electrolysis. These are called Faraday's Laws in his honor.

Michael Faraday hypothesized that electricity, water, and corrosion were somehow related. In fact, to provide electricity for his experiments he used Voltaic piles, simple batteries invented by the Italian scientist Volta. Voltaic piles consisted of alternate

International Nickel Co. photo

Photo shows magnesium blocks used to protect ships against electrolytic corrosion, before and after use. Sea corrodes magnesium instead of steel in ship's hull.

disks of copper and zinc separated by absorbent cloth soaked in salt water. Faraday noticed that as a battery wore down, the zinc would greatly corrode. This led him to connect electricity with corrosion.

Today we know that all corrosion is caused by the flow of electric current between metals and certain liquids, known as electrolytes. In an electrolyte the chemical molecules exist as positive and negative ions. When a metal is placed in an electrolyte, a voltage appears between the atoms in the metal and the ions in the liquid. Different metals will show different voltages when placed in an electrolyte. If the voltages shown by different metals are placed in order, they form the electromotive series (*see table below*). The figures given in the table are the voltages between each metal and the hydrogen ion, which is found in most solutions and liquids.

If two different metals are placed in an electrolyte and connected by a wire, a current will flow between them. This is the principle of the simple copper-zinc battery. The flow

TABLE VI. **Electromotive Series**

	Metal	Ion	Volt
	Magnesium	Mg^{++}	−2.34
	Aluminum	Al^{+++}	−1.67
	Zinc	Zn^{++}	−0.76
	Chromium	Cr^{+++}	−0.71
Base End	Iron	Fe^{++}	−0.44
	Cadmium	Cd^{++}	−0.40
	Nickel	Ni^{++}	−0.25
	Tin	Sn^{++}	−0.14
	Lead	Pb^{++}	−0.13
	Hydrogen	H^{+}	Arbitrary zero point
Noble End	Copper	Cu^{++}	+0.34
	Silver	Ag^{+}	+0.80
	Palladium	Pd^{++}	+0.83
	Mercury	Hg^{++}	+0.85
	Platinum	Pt^{++}	+1.2
	Gold	Au^{+++}	+1.42

Science World graphic

Table of voltages shown by various metals when immersed in water or acid. If two immersed metals are electrically connected, the less noble one will corrode.

of current enables the atoms in one of the metals to combine chemically with ions in the solution, forming metallic compounds. This chemical reaction and loss of metal to the solution is corrosion. According to Faraday's laws, the amount of material corroded is proportional to the amount of current passing through the metal into the solution.

Millions of "Batteries"

Even a single plate of metal can corrode in salt water. This is caused by impurities in the metal. These impurities set up voltages between different points on the metal, so that current flows between these points. As the current flows, the metal is corroded, as in a battery. Millions of such minute "batteries" on a piece of metal can gradually corrode a large surface. Scientists believe that if absolutely pure metals could be made, they would be greatly resistant to corrosion.

Alloys, a combination of two different metals, often corrode severely. Brass, for example, is a mixture of copper and zinc. When brass is immersed in sea water, the copper and zinc atoms interact with each other very rapidly. The atoms of copper and zinc form tiny electric batteries. Shipbuilders know better than to use brass screws in fastening a hull. After being in the water, the screws would become a spongy mass, with as much strength as if they were made of steel wool.

Since the day metal ships were first built, shipbuilders have been careful about placing dissimilar metals close to each other. For example, amateur shipbuilders who put an iron rudder on a boat together with a bronze propeller are in for a shock. Within a few weeks the iron rudder would look as if someone had bitten chunks out of it. In time, the rudder would disappear altogether. The iron rudder and the bronze propeller would act as two electrodes of a voltaic cell. Since the iron is electrically negative compared to the bronze, it would corrode and dissolve in the sea water while the bronze propeller remained unharmed.

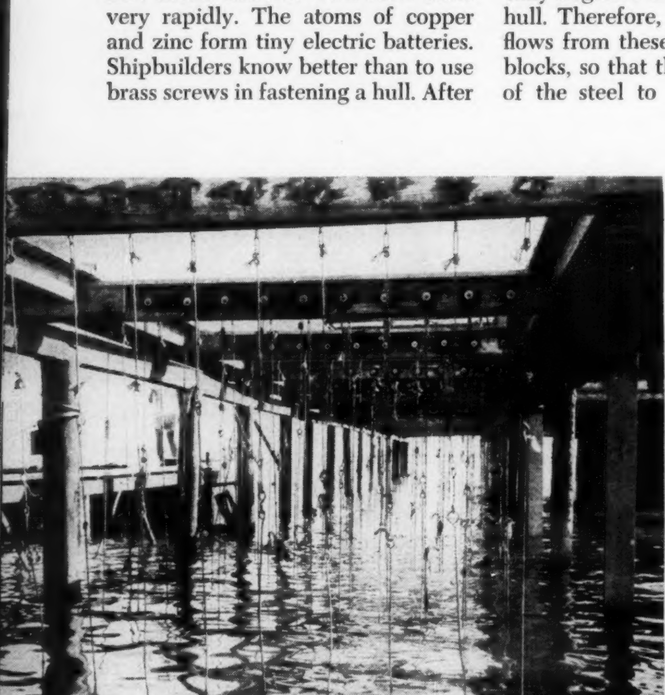
Today even large steel merchant ships with bronze propellers face this problem. The plates in the stern of the ship and the steel rudder would rapidly corrode without protection. Most large modern ships carry blocks of magnesium or zinc connected to vulnerable steel parts. These two metals are more electrically negative than is the steel in the hull. Therefore, most of the current flows from these zinc or magnesium blocks, so that they corrode in place of the steel to which they are attached. When the blocks are completely corroded, they can easily be replaced at little cost.

Corrosion occurs not only in sea water, but underground as well, especially if the earth is moist. Underground corrosion is an important problem today. We have about a million miles of buried gas, water, and oil pipelines, as well as telephone and power cables and many underground structures. All this buried material is slowly corroding, and will have to be replaced. About $600,000,000 worth of pipelines are replaced each year due to corrosion.

Experiments Underground

To fight corrosion, the National Bureau of Standards has been carrying on some of the longest scientific experiments ever devised. For 45 years the bureau has been burying samples of different materials, and digging them up years later. In 1922, for example, 37,000 specimens were buried in 95 different types of soil, all over the United States. Most of them were left buried for 17 years, and the last specimens were dug up in 1952.

The bureau found that underground corrosion was similar to corrosion in water. Most underground corrosion is an electrochemical phenomenon. The moist earth filled with



International Nickel Co. photo

***Outdoor research on corrosion*—Here ocean is a test tube. Ropes hanging from beams over the sea water hold samples of various metals, test them under natural conditions of use.**

National Bureau of Standards photos

***Indoor research on corrosion*—Wooden vat is used by National Bureau of Standards to expose steel specimens to salt water. Instruments measure electrical potentials shown by metal.**

minerals acts as an electrolyte. A voltage may appear between two points on a buried pipe. Current flows between the points through the moist earth. The more negative area corrodes through loss of metal atoms to the moist soil. The pitting type of corrosion is especially bad for pipelines which carry fluids. A small hole may mean a loss of thousands of gallons of oil.

The agents of underground corrosion are chiefly moisture, oxygen, and soluble salts in the soil. Oxygen, from the air or from compounds in the soil, stimulates corrosion by combining with metal.

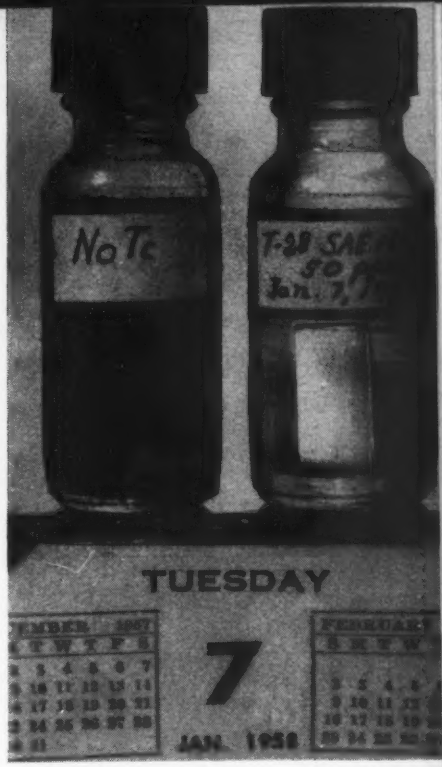
The telephone company also has had to carry out a fight against underground corrosion. It first started in 1882, when telephone poles were removed in most major cities, and telephone cables were laid underground.

Today lead sheaths surround every telephone cable in the land, under the ground or above it. The lead is sealed tight and some inactive, moisture-free gas, such as nitrogen, is pumped in under pressure. If even the minutest pinpoint holes develop in the lead sheath, the pressure of the nitrogen keeps the outside moist air from entering the lead sheath. In addition, a leak in the lead sheath means a drop in the pressure in it. By checking pressure meters installed at various points along the cable, repairmen can quickly locate the leak and plug it. In the country, one can often see cylinders of compressed gas at the base of telephone poles carrying long distance lines.

"Magic" Bottle

The fight against corrosion is being continued in the atomic age. One of the wonders of the Oak Ridge National Laboratory in Oak Ridge, Tennessee, is a small bottle on a shelf in the office of Dr. G. H. Cartledge, a member of the staff. The bottle is filled with water in which gleams a sliver of plain iron. The surface of the iron is flawless, and bright. No speck of rust floats anywhere in the bottle. It has been this way since January 7, 1953, when the bottle was first put on the shelf. The water in the bottle has been heated to boiling point many times, but the metal inside still shines like a polished mirror.

If the water in that bottle could be



Union Carbide photos from Oak Ridge Laboratories

***Right*—Slight amount of man-made element, technetium, in water in right-hand bottle has kept the piece of iron shiny and rust-free since 1953. The water in bottle at left contains no technetium. Iron has rusted, darkening water. Above—Light spots on corroding iron were made by technetium, which deposits itself on sites which tend to rust. Radioactivity of technetium exposed film.**

shaken into a million drops, 40 of the million would be a compound known as potassium pertechnetate. A few of the 40 drops would contain the element technetium, which does not exist naturally on earth. Technetium was first created in 1937 in an atom smasher, by bombarding molybdenum with deuterons.

This small trace of technetium is enough to stop rust. It is the most powerful rust-inhibitor ever discovered. Some time back Dr. Cartledge had theorized that the best known rust inhibitor known at that time, chromate, worked electrostatically. That is, there was a mutual attraction between the positive electric charges of the chromate molecule and the negative electric charges (electrons) on the surface of the iron or other metal. Because they were immobilized by this attraction, the metal electrons could not combine with oxygen in the surrounding air to form rust particles.

Dr. Cartledge hypothesized that if his theory was true for chromate, it should be even more applicable to technetium. Technetium had one more positive charge than had chromate to attract and immobilize the electrons. Dr. Cartledge carried out tests with potassium pertechnetate, a compound of technetium and potassium. The result is in the little bottle on his shelf with the shiny rust-free sliver of iron.

Why isn't technetium being used in thousands of experiments right now? Unfortunately, there is not much more than a couple of ounces of technetium in existence on the earth today. Dr. Cartledge carried out all of his experiments with only one-half gram of the element.

Mystery Still Unsolved

There is hope that more technetium may be available in the future. It accounts for 6.2 per cent of the material resulting from the breakdown of uranium-235, one of the few naturally radioactive elements. It has a half-life of 210,000 years. A great deal of technetium is locked up in the atomic wastes that have been buried underground at Oak Ridge during the last 15 years. Whether enough of it will ever be available for all the metal products in the world remains to be seen.

With more and more atomic reactors being built, it is possible that some day there may be enough technetium to preserve all our machines, ships, and automobiles forever.

Even if that never comes to pass, technetium's natural beta radiation may be very useful as a radioactive tracer to help us track down the mysteries of corrosion.

Science in the news

Plague from the Planets?

Sixty-two years ago, in *The War of the Worlds*, famous science fiction writer H. G. Wells described an invasion of Earth by Martians. The Martians were invincible and equipped to conquer the Earth. Instead they were all killed—not by man, but by the diseases of man, to which they were not immune.

This fictional menace to Martian space travelers may become a very real problem to Earth's space-bound astronauts.

According to Dr. Joshua Lederberg of Stanford University, a Nobel-Prize winning biologist, an astronaut returning from a trip to Mars, the moon, or some other planet may carry back with him germs deadly to the human race or to plants or animals. Once the astronaut landed, these deadly germs would be on the Earth for keeps. Since they would be unfamiliar to bacteriologists or virologists, it might take a long time before man learned how to control them. By that time the germs might have destroyed man's health. They might ruin agriculture, and upset the economy by destroying the balance of life on Earth.

To decontaminate a man from germs found only on Earth is already a difficult and imperfect process. To sterilize a returning astronaut of unknown foreign organisms, if they exist, would be a much *more* difficult task.

Dr. Lederberg feels that we should not bring back samples of life on other planets until we know exactly what these samples are. Although the microbes would probably be no more than dangerous parasites, the hazard is too great to take any chances.

Similarly an astronaut landing on a planet might introduce organisms from Earth which might contaminate the planet. The Earth organisms might find the planet's environment so hospitable that they would grow explosively and destroy or completely change the existing life forms.

To solve such problems, an automatic microscope could be landed gently on the surface of a planet. A sticky transparent tape would then be drawn along the planet's "ground" to collect dust samples. The tape would then be pulled under the lens of the microscope, and the resulting picture could be radioed back to Earth. The pictures would then be analyzed for microorganisms possibly harmful to life on Earth. Dr. Lederberg is presently working on such an automatic radio-controlled microscope for possible use in space.

Problems in Exobiology

Dr. Lederberg presented these problems before an international symposium organized by the Committee on Space Research, known as COSPAR. The meeting was recently held at Nice, France. The committee is made up of scientists from many nations.

Dr. Lederberg is a specialist in exobiology. Exobiology is the name for a new field of biology concerned with the study of life forms outside the Earth. It includes possible life in outer space, in meteorites, planets, or regions beyond the solar system.

Dr. Lederberg told the space scientists that the presence of bug-eyed monsters on Mars is very unlikely. If life exists on other planets, it probably consists only of microbes. But even if the planets are sterile, they may give biologists an insight into "probiotic" chemical evolution. This is the development of the complex chemical molecules which exist before the simplest forms of life come into being. Such molecules, which resemble the basic chemicals of living matter, have already been found in meteorites.

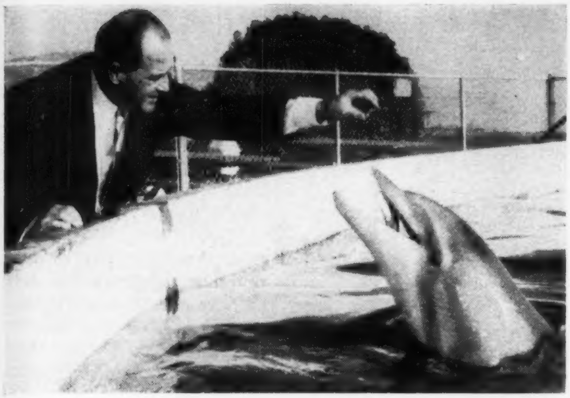
Moon Shock

Another scientist told the space experts that the first man to land on the moon may be in for the shock of his life—an electrical shock. Prof. Zbenek Kopal, an astronomer at the University of Manchester, England, said that there might be a strong positive electric charge on the surface of the moon. The charge might be caused by the impact of radiation particles from the sun striking the surface of the moon. The charge may exist to a height of about 30 feet

Algae cupcakes for space travel are cheerfully eaten by Dr. Arthur Pilgrim, biochemist who grew a new type of tasty, white algae. Ordinary green algae looks like slime, tastes like grass, but white algae is pleasant-tasting, looks like flour. His daughter baked cupcakes using 20% white algae.

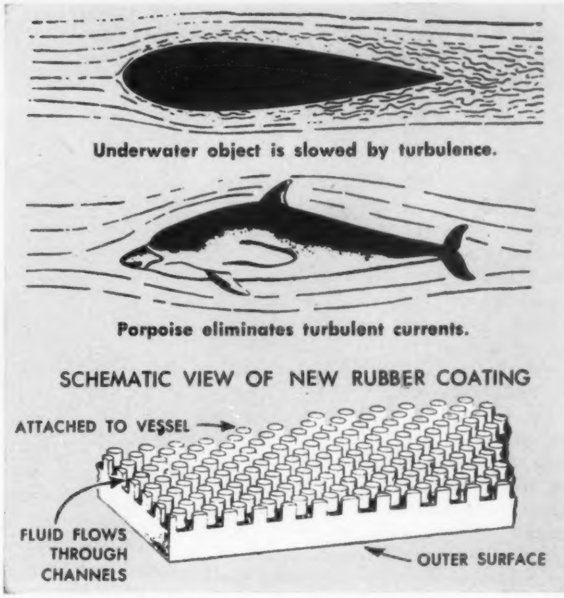
Boeing Airplane Co. photos

Food and oxygen for space travelers may one day be provided by tankful of green algae, like this one examined by Boeing scientists. Algae feed on solution of water and chemical nutrients, through which carbon dioxide is bubbled. Every five days algae are harvested, then bleached to make them edible.



U. S. Rubber Co. photo and graphic

Porpoise playing with Dr. Max Kramer gave him an idea which might double speed of submarines. Porpoise swims swiftly through water because it has elastic skin which eliminates turbulence. Dr. Kramer developed rubber "skin," similar to that of porpoise, to cover submarines. Skin has thousands of rubber pimples through which flows thick fluid, like molasses. Rubber and fluid stretch, squash turbulence, allowing a smooth flow of water, thus eliminating wasted energy.



above the surface. In landing, an astronaut might get a jolt of as much as a hundred volts.

One bit of evidence in support of this theory is the fact that radio waves are reflected from the moon as if the surface were smooth, whereas photographs of the moon definitely show a rough surface. An electrical charge on the moon would smoothly reflect radio waves, while light waves go directly through the charge to give a true picture of the surface.

In and Around the Earth

One of the byproducts of space research has been new discoveries about the Earth itself. Every time a rocket is sent up, a little more is learned about our own planet.

Strangely enough, some of the satellites which have gone deep into space have provided new information about the inside of the Earth.

Dr. John O'Keefe, of the National Aeronautics and Space Administration, closely studied the orbits of Vanguard I and other satellites. He concluded that the Earth's mantle has the strength and consistency of brick. Dr. O'Keefe based his conclusion on variations in the satellites' orbits caused by the Earth's gravity. By knowing the gravitational force on the rocket, he could theorize on the nature of the material inside the Earth.

The mantle, which extends 2,000 miles below the surface, was previously thought to flow like molasses. According to this theory, the flow of the mantle brought heat up from the Earth's core to the surface and was a cause of earthquakes. However, if it is true that the Earth's mantle is as rigid as brick, a new theory will be needed to explain the origin of earthquakes.

"Ghost" Winds

Rocket discoveries closer to the Earth were made by a Nike-Asp rocket fired 40 miles over Wallops Island, Virginia. Dr. Edward R. Manning of the Geophysics Corp. of America had equipped the rocket to leave a trail of luminous sodium vapor as it climbed. The vapor trails showed that above 80 miles, thin winds from the southwest were blowing at the astounding speed of 600 miles per hour.

No cause is known for these incredible winds, but John W. Townsend, of the National Aeronautics and Space Administration, thinks such high, warm, winds from the south might cause the sudden warm spells that occur in the middle of winter in the Northern Hemisphere.

Project Pointers

Although laboratory experiments are essential to much of the work scientists do, many of their projects are almost sheer mental activity. Perhaps you would like a "mental" science project. An example would be to list all the assumptions built into Dr. Lederberg's concern lest returning astronauts contaminate the Earth – with organisms which would cause fatal epidemics among man and his domestic plants and animals. For example, it is assumed that all organisms capable of flourishing on the Earth are not already here.

Skin for Subs

The friendly porpoise, often seen frolicking in the water alongside a passing ship, has given naval architects an idea which may double the present speed of submarines.

By covering submarines with an elastic rubber skin similar to the skin of the porpoise, the drag of the water on the submarine may be greatly reduced.

This solution to a major problem in underwater navigation was first hypothesized by Dr. Max O. Kramer, a missile scientist, while he was traveling by ship from Europe to the United States 14 years ago.

As he leaned over the ship's rail, Dr. Kramer happened to notice a school of porpoises (dolphins) passing the ship. Watching their movement, he realized that the porpoises were swimming very rapidly for animals of their size and shape. Intrigued by their amazing speed, Dr. Kramer calculated the theoretical drag of the water on the porpoises. His figures showed that the porpoises had only one tenth of the resistance to the flow of water that other similarly shaped objects would have.

After his ship landed, Dr. Kramer obtained one of the aquatic mammals to discover its secret. He found that the porpoise is completely covered with an elastic skin, one sixteenth of an inch thick, pierced by a network of ducts filled with fluid.

As the mammal courses through the water, eddies of turbulence, tiny whirlpools, begin to form around its head, caused by friction with flowing water. These eddies are similar to those found

Science in the news

in the wake of a ship. They represent wasted energy. If the porpoise's skin were rigid, the eddies would normally grow in intensity, and slow down the mammal as they flowed to its tail. The elastic ducted skin, however, keeps the eddies, or whirlpools, from growing. Instead, when an eddy forms and pushes against the skin (which creates friction), the skin yields and squashes the turbulence.

Dr. Kramer then set about utilizing the principle for underwater objects such as submarines and torpedoes. After microscopic study of the porpoise skin, he developed a thin sheet of smooth rubber with numerous little rubber pimples underneath, similar to the rubber sheet on a ping-pong paddle. In use, the smooth side of the sheet is in contact with the water, and the little rubber pimples are attached to the surface of the vessel. A viscous silicone liquid, with the consistency of molasses, flows between the rubber pimples.

This rubber skin (called Laminflo), when stretched over a model torpedo fired through the water, reduced drag by as much as 50 per cent.

The rubber skin can be applied, in principle, even to airplanes. The skin would not help ocean liners or battleships, which set waves in motion. Waves create a powerful drag on the vessel, which is not overcome by eliminating turbulence.

The new rubber skin may give submarines speeds as high as 60 knots, or about 70 miles per hour.

Project Pointers

Taking some lessons from the work that other young scientists have done with the testing of air foils in wind tunnels, why not build a "water tunnel" and test Dr. Kramer's ideas on "hydrofoils"? A pump could recirculate the water and the "hydrofoil" could be tested both as a surface and submerged "craft." How would a fur-covered hydrofoil perform? Try it with both the fur side outside and the fur side inside.

Lost Hydrogen

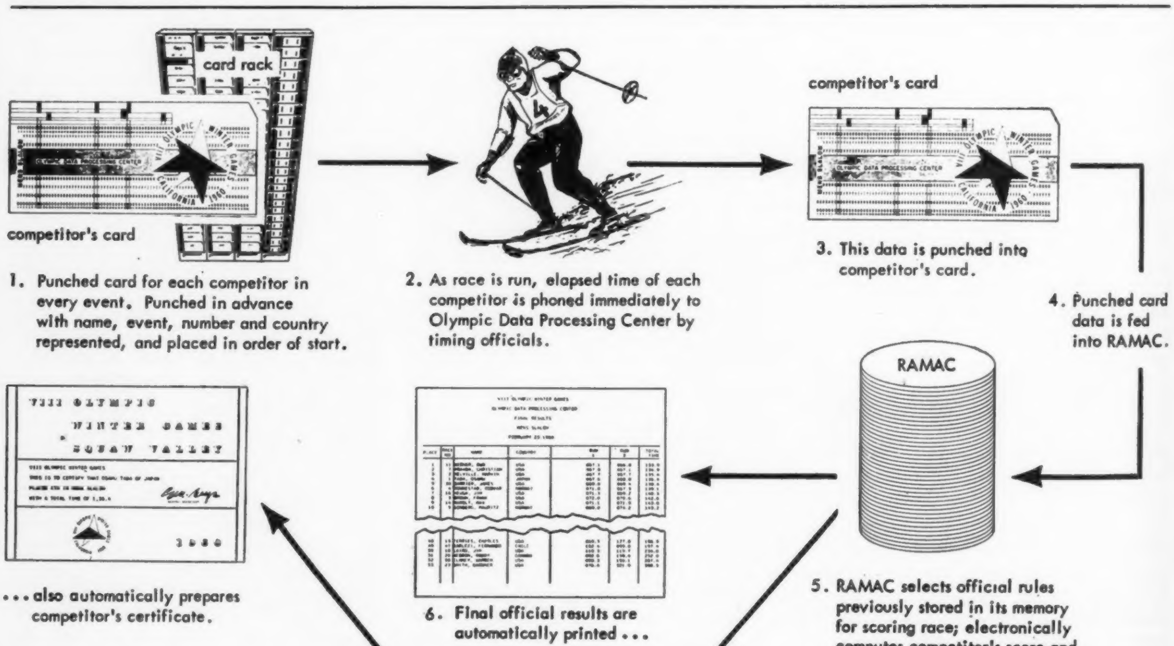
Every day a little bit of the Earth's hydrogen escapes into outer space and is lost forever to our planet.

The hydrogen makes its escape from the near-vacuum of the upper atmosphere, where a rapidly moving atom stands a good chance of traveling off into outer space.

The loss of hydrogen is small, fortunately, for without hydrogen, there would be no water on Earth, and no life as we know it. The amount of hydrogen presently being lost is minute—only enough to cause the oceans to drop 1.8 inches in a billion years.

But at one time during the history of the Earth, according to Dr. Harold C. Urey, our planet appears to have lost five to ten per cent of its hydrogen. That this could be serious is shown in the case of the planet Mars, which has not been so fortunate as the Earth. Mars has only one-tenth the mass of the Earth, and its gravity is so weak that most of its hydrogen, as well as its oxygen, has already escaped. This means that oceans on Mars probably do not exist, reducing the possibility of life on the planet.

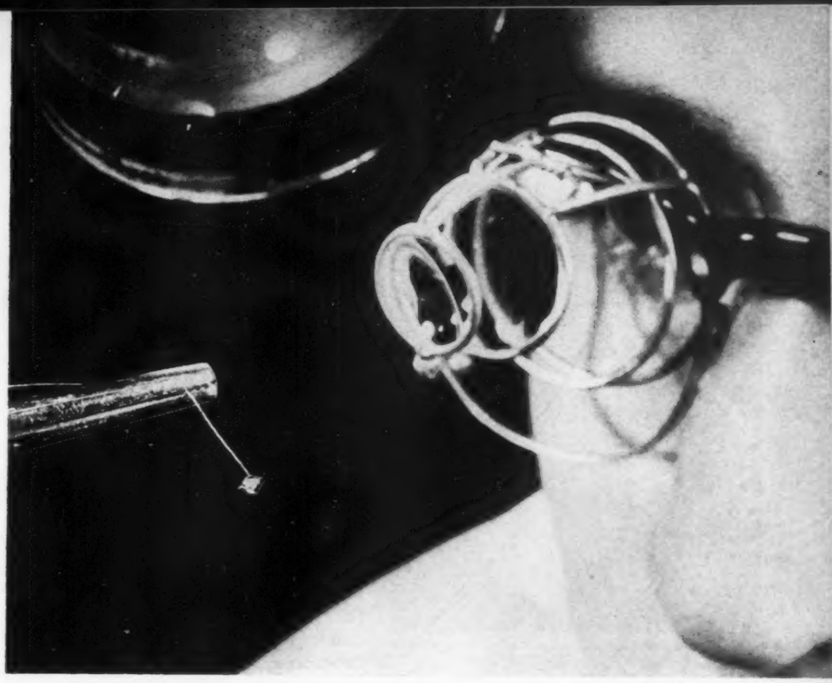
Dr. Urey, who won the Nobel Prize in Chemistry in 1934 for his discovery of heavy water, reached these conclusions by measuring the amount of water in volcanic rocks. These had been recently spewed forth from inside the Earth. He assumed that the water contained in these rocks was formed early in the Earth's history and has remained unchanged. He found that the water in such volcanic rocks contained more heavy water than did the water in the oceans.



VIII Olympic Winter Games Diagram

Contestants in Olympic Winter Games to be held Feb. 18-28 at Squaw Valley, Calif., will have their scores computed by RAMAC 305, an IBM computer. Although performance still will be rated by human judges, the machine will compute scores, compare results, determine winners minutes after an event. RAMAC uses stack of rotating magnetic disks as "memory."

Hughes Aircraft Co. photos



Tiny radiation detector, shown at end of wire *(photo at right)*, may substitute for bulky Geiger counters. The detector uses an extremely thin slice of silicon, the element used in many transistors. As the silicon is struck by charged particles, such as protons or alpha particles, it emits an electric pulse. It is extremely sensitive and needs only a small amplifier, shown in the tube *above*. Since the detection element is little larger than the head of a pin, it could be placed inside the body to measure radiation received by a cancer patient.

Heavy water contains deuterium, an isotope of hydrogen whose nucleus has one proton and one neutron instead of a single proton. Deuterium is about twice as heavy as normal hydrogen, and when it combines with oxygen it forms "heavy water." The ratio of heavy water to normal water is the same all over the oceans and in the atmosphere. However, in rocks brought up from inside the Earth, there is more normal water and less heavy water.

Dr. Urey theorizes that at one time many of the normal hydrogen atoms escaped from the Earth's atmosphere, while the deuterium atoms, which are twice as heavy, could not develop sufficent speed to overcome the Earth's gravity. As normal hydrogen escaped and deuterium was left behind, the concentration of deuterium increased, and so did the concentration of heavy water in the world's oceans. On the other hand, the water inside the Earth has remained almost unchanged ever since it was formed, and maintains its original proportions.

If it had not been for the development of plant life during the Earth's evolution, all the hydrogen might have escaped by now. However, plants enriched the atmosphere with oxygen, which trapped hydrogen by combining with it to form water. Only about one millionth of the Earth's hydrogen is presently free in the atmosphere. Also, the oxygen filters out ultraviolet rays of the sun. These would otherwise decompose the Earth's water into oxygen and hydrogen gas. The combination of these effects reduces the escape of hydrogen, so that we won't run out of water and life on Earth will continue.

Raising Ostriches

Russian researchers are studying a flock of ostriches in the belief that the birds can provide edible and nutritious meat and large eggs.

The number of eggs laid is from 16 to 24, each with an average weight of 500 grams or 17 ounces. The young chicks appear to grow rapidly in their Russian home. They grow accustomed to caretakers and are easy to herd, move about, and weigh.

One problem faced by the Russian researchers is the effect of inbreeding. Low fertility, low viability of eggs, lowered vitality of young, and greater number and variety of deformities are some of the effects. The Russians suggest bringing in outside blood for the flock. These ostriches could be brought in either from South American tropical jungles, which are their natural habitat, or from European zoos.

The researchers point out that building up a flock of the ostriches may save the bird from extinction. It has become rare in South America. They recommend construction of a special farm for semi-domesticated maintenance of the ostriches.

Project Pointers

Does inbreeding develop defects or does it merely bring out recessive characteristics? Would related but genetically healthy fruit flies, for example, if inbred for several generations produce a higher percentage of defective individuals in, say, the tenth generation, than prevails among normal wild fruit flies?

Chromosome Photos

How do cells make nucleic acid? What takes place when chromosomes duplicate? The answers to these questions may be revealed by the chromosomes themselves.

A new photographic technique for detecting and measuring the radioactive isotopes in cells and tissues, known as autoradiography, enables chromosomes to take their own photographs. Autoradiography is a technique by which a photograph is produced upon a film from rays emitted by a radioactive substance in the object to be photographed.

Metabolic events in single chromosomes as well as whole cells have been studied with this technique. Dr. J. Herbert Taylor of Columbia University reported that scientists have learned that chromosomes are composed of two sub-units of DNA (desoxyribonucleic acid). Chromosomes whose thymidine was tagged with tritium (an isotope of hydrogen) were studied during division. It was found that when the chromosome divided into two "daughters" the two sub-units were structurally different.

The cell nucleus has been shown to be the place where all, or nearly all, the RNA (ribonucleic acid) is made. The role of the nucleolus, a small dense body found in many nuclei, is also better known because of autoradiography. It appears that the nucleolus rapidly accumulates tagged RNA, which then moves into the cytoplasm surrounding the nucleus.

RNA controls cell protein production. DNA controls the material the genes are made of.

The American Museum of Natural History photo

today's scientists

DR. EVELYN SHAW... Fish Sleuth

ON ONE of Bermuda's red coral beaches an attractive young woman prepares to enter the blue Atlantic waters. She is wearing the shining, stretched plastic garb of the skin diver, a tank of compressed air on her back. In her hand she carries a special underwater motion picture camera.

She doesn't go diving for pleasure or adventure. The purpose is scientific research. The woman is Dr. Evelyn Shaw, a biologist associated with The American Museum of Natural History in New York City.

What prompts a scientist to take up the daring sport of skin diving as a tool of scientific investigation?

Dr. Shaw's research is pinpointed on fish behavior, and in the tradition of today's scientist she finds it necessary to supplement her laboratory findings by going into the field to study fish in their natural environment. Each fall, Dr. Shaw goes to the Bermuda Biological Station at St. George to photograph certain aspects of underwater life, and to conduct experiments in the enormous tanks available only at the station.

Evelyn Shaw, who was born in Jersey City, New Jersey, began her biological studies at New York University. She received her Ph.D. in 1952 and became an instructor in the biology department at Newark Colleges, Rutgers University.

Always Interested in Marine Life

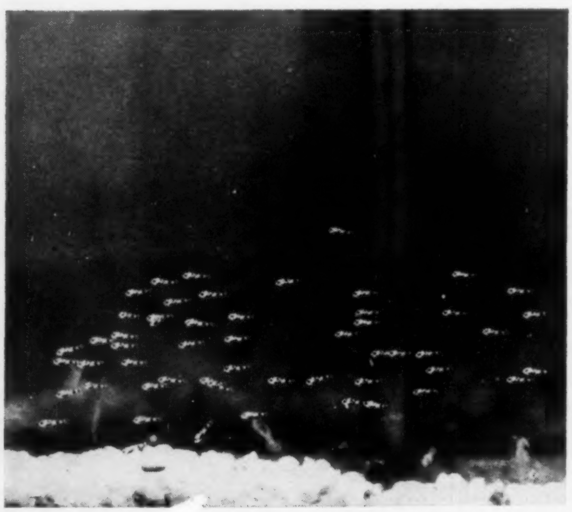
Her primary interest at that time was the embryological development of organisms. She decided to use the fish as the subject of her investigations, partly because she was extremely interested in their embryological development, and also because marine life had always interested her.

Dr. Shaw has been associated with The American Museum of Natural History since 1949, when she began work on her Ph.D. thesis. At first she studied embryology, but she became increasingly fascinated by the behavior of marine organisms, and soon found herself devoting more and more time to this field of research. She was appointed to her present position as Research Associate in 1957.

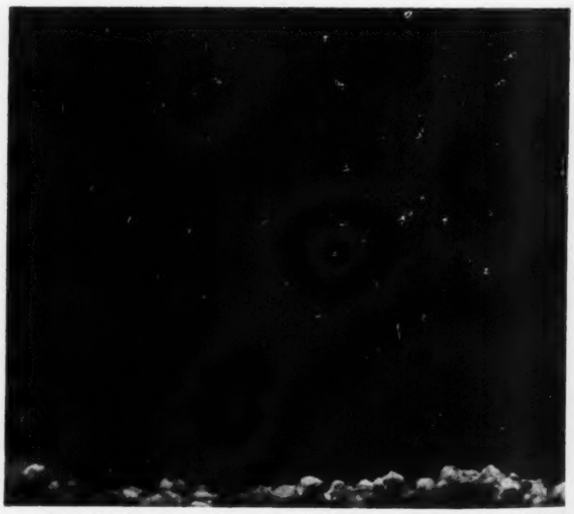
Her main interest is the schooling behavior of fish. A school of fish is a large number of fish of similar size, oriented in one direction and moving at similar rates of speed. Perhaps the most fascinating aspect of schooling is that there appears to be no leader, even in schools as large as several thousand fish. This is all the more interesting when one notices how rapidly all the fish within the school respond to changes in the behavior of other members of the school.

To study schooling, Dr. Shaw felt it was important to find out whether this behavior pattern was inborn or whether it was learned by the fish as it grew to adulthood. Amidst the steaming tropical flora in the museum's roof garden, she

(Continued on page 28)



Group of blue aca.a schools under combined incandescent and fluorescent light. Illumination affects schooling of fish.



Photos from Natural History, magazine of The American Museum of Natural History

School disperses a few seconds after fluorescent light is turned off. Grouping begins again when light is restored.

tomorrow's scientists

Project: Photomicrography

Student: Franklin King
William Penn High School
York, Pennsylvania
Science Achievement Awards Winner
Teacher: Conrad Strayer

ONE very important tool of scientists is the camera. The camera permits the scientist to keep permanent records of his observations. A very important phase of scientific photography involves taking pictures through a microscope — photomicrography. Franklin King recognized this and decided to couple his interest in science with his interest in photography, thus developing his photomicrography techniques. The result: an award-winning science project.

Franklin believes that his photographs could be used in science classes where adequate microscope facilities are unavailable. The work for his project took approximately 500 hours. He has taken more than 100 microphotographs in both color and black and white. The photographs represent subjects in botany, anatomy, zoology, and crystallography. Franklin is now interested in trying his skilled hand and eye at 8mm movies.

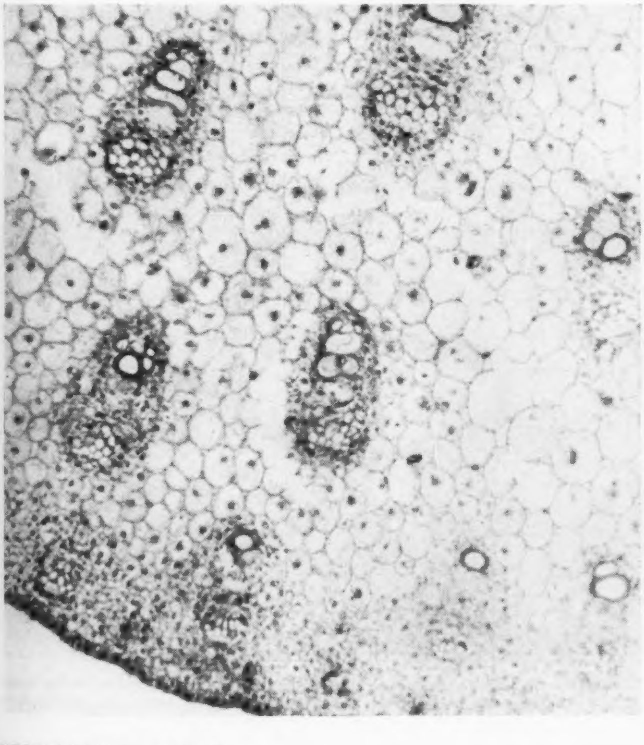
The materials which Franklin used were a microscope, camera, tripod, light source, enlarger, and developing and printing equipment. With this setup he can produce prints at magnifications up to 15,000 times.

Franklin now attends West Chester State Teachers College, and is enrolled in the science and mathematics teaching program. He intends to teach science.

"My interest in science has been with me from my elementary school days. I have always been interested in science. And having worked in a photography studio after school hours, I felt I could add something to the field of science by doing some work in photomicrography.

"My future plans are to become a science teacher so that I can help students understand and appreciate science, thereby helping to create a better world in which to live."

Good luck to you, Franklin. We wish you success in your chosen career.



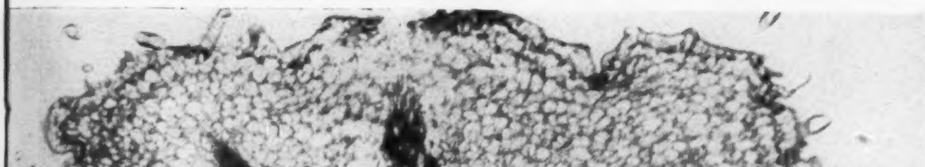
***Above*—With setup for taking photomicrographs Franklin King is able to produce prints of objects and slides at 15,000 magnification. He has made over 100 prints.**

***Left*—Photomicrograph (525X) of cross section of corn stem shows closed vascular bundles. These are common type of bundle that occurs in monocotyledonous stems.**

tomorrow's scientists

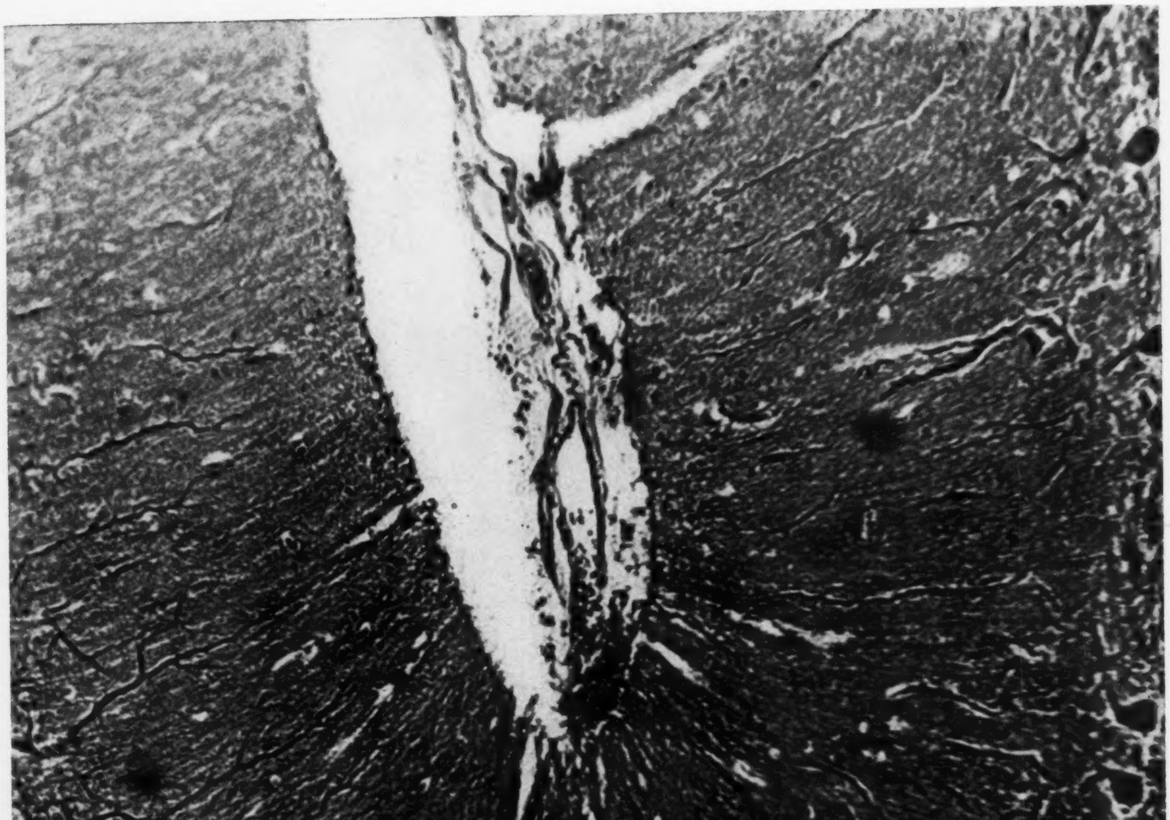
The section of mouse intestine above has been magnified 350 times. Note that inner surface is wrinkled and has fine projections. These are called *villi* and extend into intestinal cavity, giving it appearance of having velvety texture.

Crystals of silver nitrate at right form leaves and branches on copper wire that supports them. The light-sensitive crystals are used in photography. This photo shows them magnified 300 times. Franklin had to solve difficult problems of lighting and focusing before he got photos with detail at this magnification.



Cross-section of geranium bud is magnified 400X. Bud is essentially miniature shoot. Shoot is composed of groups of cells. Each group has definite function.

tomorrow's scientists



Photomicrograph of section of human cerebellum is magnified 450 times. Black pear-shaped structures are nerve cell bodies. Cerebellum is concerned with ability of the body to balance itself, and with unconscious control of the muscles.

BRAIN TEASERS

Bubble Gum Balls

Imagine ten bubble gum machines, each of which normally produces gum balls weighing one ounce apiece. Suppose one of the ten machines is defective and makes a gum ball weighing half an ounce. Using a scale, how could you find the defective machine in only one weighing, that is by using the scale only once? An unlimited number of gum balls is available from each machine.

Anthony Bellofiore
654 East 237th Street
New York 66, N. Y.

Answer: If you take one gum ball from any of the ten machines and weigh it, the chances are only one in ten that you will have found the defective machine.

However, suppose we take one ball from the first machine, two from the second machine, three from the third machine, etc., and put them all together. When we have added the last ten balls from the tenth machine we will have a total of 55 balls.

If we now weigh all 55 gum balls together, they will weigh less than 55 ounces. Every half ounce less than 55 ounces represents one defective gum ball. Therefore, the number of half-ounces less than 55 determines the number of defective gum balls. Since we took a different number of gum balls from each machine, this tells us which machine is defective. For example, if all the balls weighed 54 ounces, this would be two half ounces less than 55 ounces, meaning there were two defective balls in the batch. Since the only machine from which we took two balls was the second one, it must necessarily be the defective one.

Wrong Labels

Suppose you are given three boxes; one containing two black marbles, one containing two white marbles, and the third containing one black and one white marble. The boxes are labeled BB, WW, and BW, but each box is incorrectly labeled. By taking only one marble from one of the three boxes you should be able to determine the contents of all the boxes if you're smart!

Robert Kaplan
Albert Leonard Jr. High School
New Rochelle, N. Y.

Answer: Draw a marble from the box marked BW. Suppose it is black. This means the other marble in the box must be black, or the label would be correct. Therefore this box should correctly be BB. We also know now the contents of the box labeled WW. It cannot contain two black marbles, since these were already determined to be in the first box. But it cannot contain two white marbles either, because the label would then be correct. Therefore, it must contain a black and a white. Hence, the third box obviously contains two white marbles. The same reasoning can be used if a white marble is drawn in the beginning. Try it.

Magic Square

Draw a checkerboard with three squares on a side. In each square write one of the numbers from one to ten, using each number only once. Arrange the numbers so that their sum along any vertical column or horizontal row equals fifteen, as well as their sum along the diagonals from corner to corner.

Dave Cvelbar
Brookfield Junior High School
Brookfield, Ohio

Answer: When the numbers are arranged in this way they form what used to be known as a "magic square." At one time many people believed that such an arrangement of numbers had magical powers. Several different squares can be constructed. One solution to the problem is given below. Try to find other arrangements which will solve the problem. Magic squares which add up to other sums can also be constructed.

1	10	4
8	5	2
6	0	9

Take a Walk

If you walk 100 miles east, 100 miles south, 100 miles west, and 100 miles north, will you end up at your starting point?

Sam Couch
Hall Fletcher Jr. High School
Asheville, North Carolina

Answer: If you were walking on perfectly flat ground you would end up at your starting point. However, if you were walking on a curved surface, such as the surface of the earth, your walk would finish at a different point. This is because the north-south lines of longitude are not parallel, and your walk would not form a square. However, if you start your walk from certain points on the earth, you would finish at the place you started. Can you figure out what these points are? (Hint: They are near the Equator. See if you can find any points away from the Equator which fit the conditions stated in the problem.)

Ancient Coin

An archeologist claimed that he found some coins dated 46 B.C. However, one of his smart students immediately realized that the archeologist was not telling the truth. How did he know that the date was wrong?

Barbara Preece
Sudbrook Jr. High School
Baltimore, Maryland

Answer: The student knew that in 46 B.C. the division of the years between B.C. and A.D. had not yet been made. If the coin had really been struck in 46 B.C., its maker would not have known that it was B.C., and would have counted the years according to his own ancient calendar.

Send in Your Favorite Brainteaser

You surely have a favorite brainteaser that you would like to share with other readers. Send the brainteaser, together with the solution, to Science World, *33 West 42nd Street, New York 36, N. Y. We will pay $5 for every brainteaser published. Include the name of your school, in addition to your home address, and state your age.*

Meeting the Test

Comprehending Scientific Reading

By THEODORE BENJAMIN

HAVE you ever noticed the difference between the way you read a novel and the way you read scientific literature? The novel lends itself to the technique of "skimming," while scientific reading requires a need to pause between each sentence to assimilate the ideas and to assess their implications.

In many of the newer types of examinations, the test may place much emphasis on your ability to handle "work type" reading. The student is usually given a passage containing unfamiliar content. The words and terms used are either known or defined within the passage, but the ideas they form will generally be outside the experience of the reader. Questions are then asked concerning the content of the passage or inferences from the content.

Try your hand at the following passage and answer the questions pertaining to it.

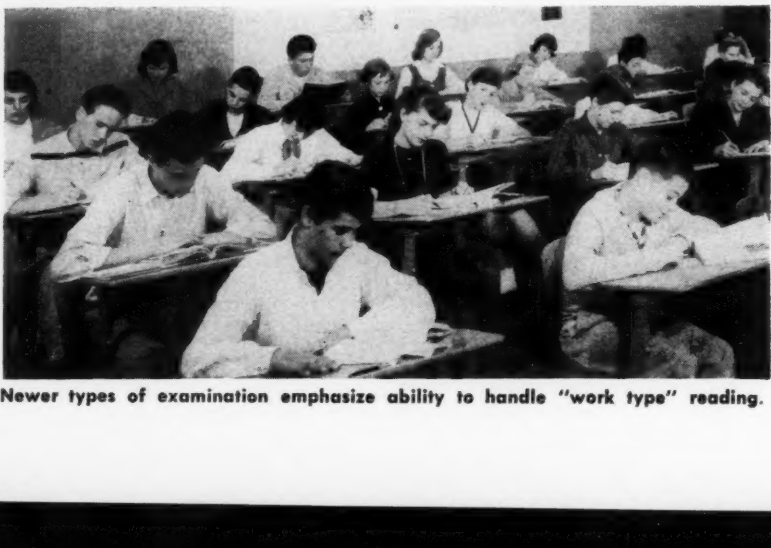
Checking Predictions of Relativity

A prediction of the general theory of relativity states that in the vicinity of a large mass, electron vibration and any other periodic motion should be slowed down. Thus, for example, a neon atom emitting a given frequency of light near the surface of the earth should emit a higher frequency if it were well away from the earth's gravitational field.

The difficulty in experimentally demonstrating this effect is readily seen when we find that the theory predicts that for each mile from the earth's surface we take the radiating atom, the change in frequency should be only one part in 5,000 billion. Most substances do not emit a precise enough frequency to permit us to detect such a narrow shift. The normal frequency spread within any given radiation line is much greater than the sought for difference.

It has been recently found, however, that a crystalline solid containing radioactive iron-57 emits gamma radiation of an exact and very narrow frequency range. The frequency of this radiation is precisely a given value with negligible spread or "smear." Furthermore, a second crystal of the same material will absorb this particular frequency almost completely. This is essentially the phenomenon of resonance, one in which a material absorbs the very frequencies it would give out if it were vibrating.

A proposed experiment to check the prediction of general relativity would work something like this: A crystal emitting this sharply defined gamma ray frequency would be placed on a horizontal line with a second crystal and the intensity of the radiation penetrating the second crystal would then be measured. Since the second crystal is "tuned" to or is in resonance with the frequency of the gamma rays from the first crystal, practically all of the radiation striking the second crystal would be absorbed and little would pass through. If the emitting crystal is now placed above the second crystal, the decreased gravitational field surrounding the raised upper crystal would cause the frequency of the gamma radiation to increase. The second crystal, no longer in "tune" with the shorter wave gamma radiation striking it, would no longer absorb the radiation as completely as before. In fact, theoretically a fall of 3 meters between the source and the absorber should reduce the absorption of iron-57 radiation by half. In this way we may verify this aspect of the general theory of relativity within a room only several meters high.



Newer types of examination emphasize ability to handle "work type" reading.

Test Yourself

On the line to the left of each of the following statements write the letter T or F to indicate whether the statement is true according to the information given, bearing in mind any inferences that may be drawn from the foregoing passage.

__1. Iron-57 is radioactive.

__2. The theory indicates that a clock on the earth should run slower than a clock in an earth satellite, stationary with reference to the earth and 23,000 miles from the earth's surface.

__3. The general theory of relativity has implications which require us to examine our concept of the nature of time.

__4. Resonance requires that two bodies be identical in all respects.

__5. If the contemplated experiment is successful, the general theory of relativity will have been proved beyond any dispute.

__6. According to the theory of relativity, a gravitational field has no effect on radiation.

__7. Visible light originating in the sun will appear to shift in frequency toward the violet end of the spectrum when observed at some distance from the sun.

Answers

1-T; 2-T; 3-T; 4-F; 5-F; 6-F; 7-F.

IT HAPPENS BEFORE ENLISTMENT!

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GRADUATE SPECIALIST **US ARMY**

Electronics Repairman

Project and Club News

Professional Help for Future Scientists

THE Junior Science Club of New Rochelle, N. Y., publishes *Non-Edit,* a bi-weekly news letter filled with ideas for other groups.

For example, a recent news item reports the trip of six club members to Brookhaven National Laboratories at Upton, New York, and their recommendation that this trip should be a major event for the entire club next year.

The club's new Biochemistry Interest group met with Dr. Maclyn McCarty of the Rockefeller Institute and Dr. Joseph L. Owades of the Schwarz Laboratories to discuss the functions of enzyme systems. Organized study of biochemistry was scheduled to begin with "Proteins and Their Structures."

Other interest groups within the club include Genetics, Astronomy, Laws of Motion, Group Theory, Symbolic Logic, Algorithms and Construction (for younger members), and Analysis (chemistry). Topology, Probability, and Set Theory groups are proposed.

Cash Grants for Projects

The Knoxville (Tenn.) Junior Academy of Science, which recently became a member of Science Clubs of America, has established an Incentive Awards program to give cash grants to students for use in financing projects in science and other fields of scholarship.

Each application for a grant must be endorsed by an adult qualified in the field of the student's project. A committee of Junior Academy members awards the grants to high school students, basing decisions on written application and on interviews. Completed projects become the property of the Academy to be used in its museum program.

This club selects a science "Teacher of the Month," who is honored in its monthly news letter, *Junior Science*.

In many parts of the country professional scientists have set up coordinated centers for scientific information, assistance, and special programs designed to help and encourage students interested in science.

In Washington, D. C., for example, all the scientific, technical, architectural, and engineering societies have set up a Joint Board on Science Education. At least one scientist is assigned to every junior and senior high school in Washington and all of its surrounding counties. Students have free access to this "Contact" scientist, who may refer the student to a specialist in the field of the student's individual interest or problem. Directories of the key people in the organization are provided for each school in the area.

The Joint Board publishes a newsletter for science and mathematics teachers and a series of science project outlines contributed by scientists.

Saturday Seminars

In Worcester, Mass., seminars are held on Saturday mornings in a number of schools for students in many fields of science. One school will have six to eight seminars in chemistry, another in botany, a third in physics, a fourth in mathematics, etc. Specialists talk with the students at each of the sessions. Project clinics are a part of the weekly meetings. Similar programs are conducted in other parts of the country.

Kansas City has a year-round program that includes a summer job program which offers student-trainee positions in industrial and scientific laboratories to students who show ability at science fairs.

In many cities and towns organized field trips and classes are conducted where specialties are stressed; for example, telescope making, microscopy, ornithology, pond life, etc.

Your science club may be able to stimulate the formation of coordinated professional programs for students if none exist in your community.

Answers to Crossword Puzzle

(See page 31)

E	D	I	S	O	N		L	I	S	T	E	R
D		F	A	N		J		T	A	B		O
W	R				T	O	E		T		P	E
A	I	M		H	O	N	E	Y		H	I	M
R	G		C		P	A	N		M		T	E
D		R	U	G		S		T	A	U		R
	B	A	R	O	N		M	O	R	S	E	
T		P	I	T		J		T	I	N		W
H	O		E		T	A	B		E		A	A
O	D	D		C	O	M	E	T		A	R	T
M	E		Y		N	E	T		S		C	S
A		I	O	N		S		B	E	E		O
S	A	M	U	E	L		N	E	W	T	O	N

Fish Sleuth

(Continued from page 20)

was given a lab in which to investigate this phenomenon. She separated a number of newly hatched fish from the rest of their group and raised each fish in a separate tank. She coated the sides of each tank with wax so that the fish were unable to see even their own reflection. When they reached adulthood the fish were returned to the schooling group.

Dr. Shaw found that after only a few hours they had learned to school and could swim quite well with the rest of the group. This experiment suggested that, at the very least, fish were able to adapt readily to this behavior pattern. To follow up her findings, she took another group of fish that had been raised in individual tanks and put them together with each other, *but not with a school*. These fish did not school. Each swam along its own random path, unaware of the direction being taken by any of the other fish.

This established that schooling behavior is affected by surrounding environmental conditions, and that fish reared away from other fish were able to acquire it quite rapidly.

What enabled the fish to learn to school, and having learned it, what enabled the fish to have such a keen awareness of even the slightest movements of the entire school?

Effect of Light on Schooling

Many scientists hypothesize that vision is the sole factor involved in schooling. Dr. Shaw, however, suggests from several experiments that vision is important but does not appear to be the sole factor.

"I studied this by separating a group of fish from each other by panes of transparent glass put lengthwise into one large tank," explains Dr. Shaw. "Each fish could see the others but each was actually in a separate tank. The fish continued to school. I then replaced the transparent glass with dark glass so that the fish could no longer see one another. Schooling did not occur."

These experiments confirmed that vision may have a good deal to do with schooling. However, in the experiment using the transparent glass Dr. Shaw noticed that although the fish did school and followed one another, their responses were slower than when all of them were in the same tank. It is this aspect of schooling that she is investigating at present. Are water currents created by the movement of the fish as they change their direction of travel? Are these currents communicated to the other fish? Preliminary experiments

seem to suggest that this theory is correct.

In a small attic laboratory Dr. Shaw set up an experiment in a specially designed circular tank to examine the effect of light on schooling. Directly above the tank there is a large circular fluorescent light. On the ceiling of the room in which the tank is housed is a 300-watt incandescent light, which is kept on throughout the experiment, so that the tank is never in total darkness. When the fluorescent light is turned on the fish school immediately. When it is turned off the school disperses, although the incandescent light remains on. It is not until the fluorescent light is turned on again that the school reforms.

This pattern of behavior seems to correspond to the behavior of fish in their natural habitat. With the coming of darkness, schools tend to disperse, and do not form again until the coming of morning. On particularly clear, sunny days the responses of the school appear much quicker than on cloudy days. From these observations and experiments Dr. Shaw theorizes that wave length and intensity of light may have an important bearing on schooling.

Women Scientists—Also Homemakers

This research is aimed, primarily, at a basic understanding of the behavior of organisms, but like so much other basic research it also has practical importance. If our expanding world population increases the demands on insufficient land resources, man will have to turn more and more to the sea for his food supply. The implications of Dr. Shaw's findings may have a far-reaching effect on an approach to this problem.

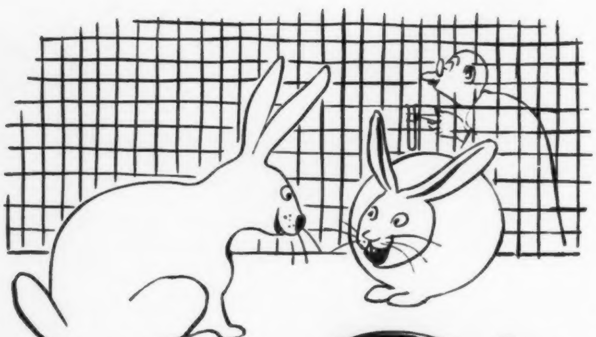
An extremely attractive woman, who looks more like a fashion expert than a scientist, Evelyn Shaw is also a full-time homemaker. She is the mother of three children, two boys aged 4 and 6 and a girl aged 8, who have a wonderful time accompanying their mother on all her research trips. She is an excellent cook, especially of foreign dishes.

Discussing woman's role in science, she says: "In the laboratory, doing scientific research, she is a scientist and no distinction must be made between a woman or a man scientist. She is a woman at home, with her family, taking care of her house and children. I don't believe that women need to be encouraged to go into science—they are enthusiastic and interested from the beginning. What needs to be encouraged in women is the belief that they can be dedicated scientists and still have time for a home and family."

Evelyn Shaw is living proof that this is possible.

—Frances Gudemann

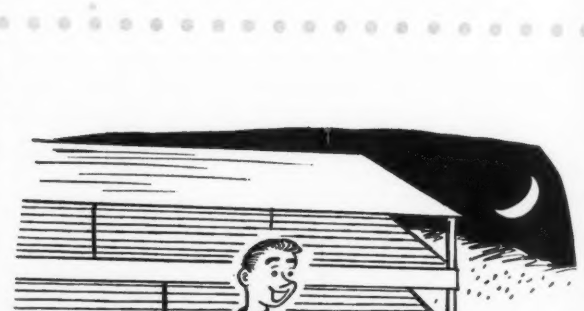
sci-fun



"I'm gonna play dead. Watch the professor's face fall."

"For Heaven's sake, Robert, comb your hair and come to supper."

". . . and have you noticed any effects from a steady diet of walrus meat, Professor?"



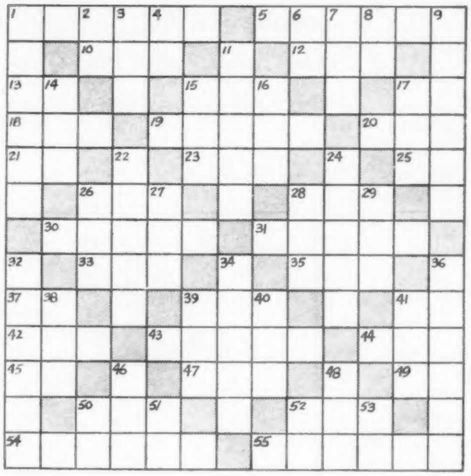
"Want a race? All that horsepower against the beam from my little two-cell flashlight."

Famous Scientists and Inventors

By Carolyn Bishoff, Paul Junior High School, Washington, D. C.

★Starred words refer to scientists and inventors

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzle cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. Answers to this puzzle are on page 28.



ACROSS

- *1. Inventor of the incandescent electric light bulb.
- *5. Founder of antiseptic surgery.
- 10. It produces air currents.
- 12. Book club sponsored by *Scholastic Magazines* (*abbr.*).
- *13. German scientist who discovered X rays (*initials*).
- 15. Terminal digit of the foot.
- *17. German bacteriologist who founded chemotherapy (*initials*).
- 18. Ready, ________, fire.
- 19. Manufactured by bees.
- 20. Homonym for *hymn*.
- *21. American who invented a type of machine gun, __ichard __atling.
- 23. From the frying ______ into the fire.
- *25. Inventor of the phonograph (*initials*).
- 26. Covering for the floor.
- 28. Nineteenth letter of Greek alphabet.
- *30. Title of No. 5 Across.
- *31. Inventor of the telegraph.
- 33. "The ________ and the Pendulum."
- 35. Metal used to coat cans.
- *37. Dane who discovered that every conductor carrying an electric current is surrounded by a magnetic field (*initials*).
- 39. Small loop for pulling something.
- *41. His experiments made possible the invention of the astatic galvanometer (*initials*).
- 42. Eccentric.
- *43. Edmund Halley named one of these.
- 44. Work of an artist.
- 45. The Pine Tree State (*abbr.*).
- 47. Fabric used to catch fish.
- *49. German-American electrical engineer who worked with man-made lightning (*initials*).
- 50. Electrically charged atom.
- 52. It lives in a hive.
- *54. First name of No. 31 Across.
- *55. He formulated the law of gravity.

DOWN

- *1. He developed a vaccine for smallpox (*first name*).
- 2. Whether.
- 3. Unhappy.
- 4. "________ top of the world."
- *6. Galileo lived in this country (*abbr.*).
- 7. Seated oneself.
- *8. Koch discovered the germ responsible for this lung disease (*abbr.*).
- *9. This Danish astronomer made the earliest attempt to measure the speed of light.
- *11. He developed a vaccine against polio (*first name*).
- 14. Equip.
- 15. Opposite of *bottom*.
- 16. Even (*poetic*).
- 17. Deep hole in the ground.
- *22. She discovered radium.
- *24. First name of No. 22 Down.
- 26. A quick, smart blow.
- 27. "I've ________ plenty of nothing."
- 28. Infant.
- 29. United States Navy (*abbr.*).
- *32. He made early improvements on the steam engine, ________Newcomen.
- *34. He perfected the steam engine (*first name*).
- *36. Famous assistant of Alexander Graham Bell.
- 38. Poem by John Keats, "________ to a Nightingale."
- 39. Two thousand pounds equal this.
- 40. Wager.
- 41. Sustained bow of light formed between two incandescent electrodes.
- 46. "________ Are My Sunshine."
- 48. Mend with needle and thread.
- 50. I am (*contraction*).
- 51. Neon (*chemical symbol*).
- 52. Beryllium (*chemical symbol*).
- *53. Italian physicist who invented the barometer (*initials*).

of development enhance the effectiveness of the presentation.

The classic experiment performed by Hans Spemann at the beginning of this century as well as the up-to-the-minute research of Dr. James Ebert and Dr. Robert DeHaan are included. Students who regularly watch CBS-TV's *Conquest* series, sponsored by Monsanto Chemical Company, will be familiar with Dr. Ebert and Dr. DeHaan.

The article may also serve as an excellent springboard for student projects and classroom demonstrations. Observing a chick come into the world is a sight few students ever forget. This article may be used to motivate a class to build an incubator and keep day-to-day records of the incubating eggs.

After 36 hours, the egg's contents may easily be examined. Permanent slides may be made of embryos in various stages of development. For details on how to care for eggs and make slides of them, *A Sourcebook for the Biological Sciences*, by Morholt, Brandwein and Joseph, gives excellent directions and has an extensive bibliography for further work in embryology.

Students may also study the development of the sea urchin, which is representative of animal development. Sea urchin eggs are especially valuable as experimental material for studying embryological and physiological problems. The eggs may be centrifuged until the cell splits in two. Nucleated halves will develop into normal embryos. Enucleated halves will also develop but they will produce disorganized embryos.

To show the sensitivity of sea urchin embryos to chemical and physical changes in the sea water in which they develop, rear some eggs in sea water diluted with distilled water to 95 per cent of its salt concentration. Rear others in 100 per cent sea water and some in 105 per cent sea water. Students will be able to observe the results through a microscope.

Clay models representing various stages in the development of an embryo may also be made by students, and these models used for classroom demonstrations and reports. Reports on recent research in embryology may round out the topic.

Topics for Discussion

1. What is cell differentiation?
2. How does a fetus differ from an embryo?
3. By what chemical means can an egg cell be stimulated to develop?
4. What questions are embryologists trying to answer?
5. How is the study of cancer related to the study of embryology?

—S.S.

TO SPICE YOUR SCIENCE LESSONS

In (subject)	When Teaching (topic)	Why not bring in news item (from this issue)
Earth Science	Shape of the Earth	In and Around the Earth
	Movements of the Atmosphere	Ghost Winds
Biology	Balance of Life (ecology)	Plague from the Planets
	Immunity	Plague from the Planets
	Cell Structure	Chromosome Photos
	Mitosis	Chromosome Photos
	Genetics	Chromosome Photos
	Conservation	Raising Ostriches
	Animal Breeding	Raising Ostriches
Physics	Electrostatics	Moon Shock
	Gravitation	In and Around the World
	Uses of Radioactive Isotopes	Chromosome Photos
	Aerodynamics (friction, turbulence, drag)	Skin for Subs
Chemistry	Radioactive Elements as Tracers	Chromosome Photos
General Science	Gravity	In and Around the Earth
	The Earth's Interior	In and Around the Earth
	Exploring Space	In and Around the Earth
	Weather	Ghost Winds
	Infectious Diseases	Plague from the Planets

RLD